The Role of Sectoral Approaches and Agreements

Focus on the Steel Sector in China and India

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Preface

This report forms the first output from of a wider Climate Strategies project on 'International Sectoral Approaches and Agreements: Steel sector in China, India and Japan' which is due for completion in 2010.

The steel sector was chosen as the focus of the study because carbon costs could become a large component of its overall cost and it is widely traded. It accounts for around 5% of global CO₂ emissions from fossil fuel combustion, its emissions are projected to grow and our earlier research on competitiveness dimensions of emissions trading, and on tackling carbon leakage, highlighted steel as a crucial sector in the global challenge, probably the most vulnerable to 'carbon leakage'.

Yet steel remains produced at widely different levels of energy and carbon efficiency around the world, and this together with the variety of processes involved makes it important to expand efforts to tackle its emissions.

These factors make it a prime sector for exploring potential sectoral approaches. There has been considerable debate about sectoral approaches and sector agreements in global negotiations, but without much clarity as to their possible content. This underlies the need for an interim report to examine the key practical considerations for developing a sectoral approach that is palatable to multiple parties.

Climate Strategies is grateful to its core supporters for funding, and particularly to the UK Department of Energy and Climate Change who provided specific funding to enable this report to be produced in advance of 15th Conference of the Parties in December.

Climate Strategies commissioned Peter Wooders to lead the project. His Senior Economist position at IISD coupled with 20 years of industry research experience has ensured the content of the project is both comprehensive and rigorous. We are grateful to Peter for producing this high-quality piece of research in a very tight timeframe, and we are also grateful to his team of co-authors; Greg Cook, Paul Zakkour, Mike Harfoot and Seton Stiebert for their valuable contributions to the project. The views expressed in this report, of course, remain those of the authors.

Further component studies are expected to follow during 2010, so as to build up a broad and fact-based assessment of the issues and options around global sectoral approaches agreements in steel as part of our contribution to the ongoing international debate.

Michael Grubb
Chair of Climate Strategies
The Role of Sectoral Approaches and Agreements

Focus on the Steel Sector in China and India

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Executive Summary

Key Insights on the steel sector in India and China

- **Steel is an important sector in terms of carbon emissions and its abatement:** It accounts for 5% of global emissions from fossil fuel combustion; its emissions are projected to grow by at least 50% in the period 2005-30, even if emission abatement options are implemented; and the sector is vulnerable to emissions leakage (40% of steel is currently traded internationally).

- **China is the world market leader in steel, with India on a high growth path.** China produces around 500 million tonnes /yr (40% of world market share) and India 55 million tonnes /yr. They are both projected to grow substantially.

- **There are abatement activities already underway as part of business of usual in China and India, but there is still scope for incentivising more through Sectoral Approaches and Agreements.** These should incentivise governments to focus on removing non-price barriers (such as access to investment finance) in addition to strengthening the carbon price signal.

- **Much of the new build in China and India is already taking place at best available technology (BAT).** Abatement potential from improving new build is thus limited. Other abatement options involve improving efficiency at existing plants, replacing older, less efficient plant and increasing scrap recycling. These are considered to have low or zero marginal abatement costs, but encounter barriers including high capital costs.

- **In general, there do not seem to be many deep abatement opportunities in steel in the short-medium term.** This sector, with its ‘locked-in’ technology, perhaps has more in common with aviation than with say power generation that has more technology options that could radically reduce emissions. Excluding demand reduction, CCS (carbon capture and storage) and other breakthrough technologies are necessary for deep cuts but are unlikely to be relevant before at least 2020.

- **There is considerable uncertainty in estimating what the scale of abatement could be, what the business-as-usual baseline is, what the target should be against which credit would be given and how sectoral approaches and agreements may impact take-up.** Initial modelling suggests that, within a decade, China could abate up to 150 MtCO₂/year and India up to 40 MtCO₂. If a target were set in the middle of a range defined by a baseline based on stock turnover only and a projection with the maximum identified abatement, and if the carbon price were $25/tCO₂, China could harness up to $2bn per annum from the sale of credits, and India up to $0.5bn. Where the baseline and targets would be set would be a result of negotiation.

Abatement options in the steel sector

- **This study identifies six possible categories of CO₂ abatement** (see Table 1). The first four of these are available now. The final two need further development (almost certainly via international co-operation); their large-scale implementation is likely to be many years away.

<table>
<thead>
<tr>
<th>Abatement Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The closure of inefficient, highly polluting plant</td>
</tr>
<tr>
<td>2. Improving energy efficiency and carbon efficiency at existing, non-obsolelte plant</td>
</tr>
<tr>
<td>3. Ensuring that new plant is built using best available technology</td>
</tr>
<tr>
<td>4. Increasing the use of recycled scrap</td>
</tr>
<tr>
<td>5. Adopting Carbon Capture &amp; Storage (CCS)</td>
</tr>
<tr>
<td>6. Developing and implementing breakthrough technologies</td>
</tr>
</tbody>
</table>

- The costs of abatement are uncertain: a large proportion of the abatement options currently available are likely to be small and may be positive or negative - they have positive net returns. It is concluded that the costs are close to zero.
• Barriers to the uptake of abatement are largely the need for additional policy and scarcity of investment capital. Whilst a carbon price would provide some incentive to reduce emissions, on its own it is unlikely to lead to significant emission reduction at current EU ETS prices.

• Using scrap steel as the primary input (to an Electric Arc Furnace) avoids approximately 80% of the emissions associated when starting the process with the input of iron ore (using a Blast Furnace or equivalent). There is some potential to increase the quantity of scrap recycled but in part this relies on development: it is more difficult to find scrap in countries which are rapidly developing as they do not have a ready source of used assets for scrap.

• Significant emission reductions will require the implementation of carbon capture & storage (CCS), breakthrough technologies or demand reduction.

• Capacity-building is needed in developing countries to better identify challenges and opportunities and to access the persuasive power of data collection and self-assessment in plants.

Potential Abatement and Financial Flows in the steel sector in China

China’s steel-making capacity has grown rapidly and its current production is around 500 Mt/year (40% of world total). It is projected to saturate within the next 20 years at around 650 Mt/year. New build in China is almost exclusively based on Blast Furnaces: these are considered to be built to best global standards. A significant share of existing capacity is small and highly polluting – China is already implementing retirement policies for plant whose performance is considered to be unacceptable. It is considered that the Chinese government could assume responsibility for an agreement covering the steel sector as a whole.

Table 2 shows current status against each of the four currently available abatement categories. The Table identifies potential further policies and support required to incentivise increased abatement and the MRV issues associated with implementation. It should be noted that regulation and other non-financial measures could also support implementation.

Table 2 Specific policies and measures recommended for China

<table>
<thead>
<tr>
<th>Abatement Category</th>
<th>Existing policies and support</th>
<th>Further policies and support</th>
<th>MRV Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The closure of inefficient, highly polluting plant</td>
<td>China already implementing policy</td>
<td>Make payments based on faster reduction in production than current policy</td>
<td>Definition of obsolete plant. Verified production figures. Baseline of planned reduction in production</td>
</tr>
<tr>
<td>2. Improving energy efficiency and carbon efficiency at existing, non-obsolete plant</td>
<td>Some investments being made under Chinese policy and CDM. Lack of investment capital</td>
<td>Project-based scheme (e.g. continuation of CDM). Supplemented by financial support scheme, ideally low cost capital</td>
<td>As per the CDM – baseline, methodology, additionality</td>
</tr>
<tr>
<td>3. Ensuring that new plant is built using best available technology</td>
<td>Believed that China is already building to best global standard</td>
<td>Consider partial investment credit (e.g. low cost capital) if new plant is best available technology</td>
<td>Need to audit plant on its completion. Ideally performance would also be verified at later date(s)</td>
</tr>
<tr>
<td>4. Increasing the use of recycled scrap</td>
<td>China recycling rate low by international standards – expected in a rapidly developing country</td>
<td>Make payments against increased rates of collection made, within China only (to avoid leakage)</td>
<td>Baseline of existing collection rate. Verified quantity collected. Verification sold to and used by Chinese steel plant</td>
</tr>
</tbody>
</table>

1 Note that this option is potentially very expensive and may not yield significant carbon emission reductions.
The study has estimated what these four items may deliver in terms of emission reductions against an arbitrarily set ‘stock turnover’ baseline, whereby emissions are projected on the basis of plant retirement and new build only\(^2\) (i.e., without any specific emission reduction policies). In reality, current Chinese policy would already move us away from this baseline and it is difficult to estimate what this deviation would actually be. Figure 1 illustrates the results of this calculation. Additional scrap recycling becomes the dominant contributor in later years. The total abatement potential, compared to a baseline of stock turnover, is estimated at around 150 MtCO\(_2\) per year.

Figure 1 China Abatement Potential, relative to a Stock Turnover baseline

Figure 2 shows the impact these ‘Maximum Identified Abatement’ measures would have against a stock turnover baseline. In order to illustrate potential financial flows, it has been assumed that China could receive payment against an ‘Illustrative Sector No Lose Target’ set midway between the stock turnover and maximum identified abatement lines. At a carbon price of $25/tCO\(_2\), illustrative financial flows to China from the sale of credits would be around $2bn per year from 10 years onwards.

Figure 2 Potential Improvement in Emissions beyond Stock Turnover for China Steel Sector

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\(^2\) New build (of Blast Furnaces) is assumed to be essentially at BAT in China. It is assumed that this is at a typical international level of 1.8 tCO\(_2\)/t steel. We postulate that up to a further 0.1 tCO\(_2\)/t steel could be squeezed out with some policy and other support. This represents an upper limit on the potential savings.
Potential Abatement and Financial Flows in the steel sector in India

India's steel capacity is currently around 55 Mt/year, i.e. one-tenth of China. The mixture of plant is highly varied, in terms of size, technology, ownership and emissions performance. Projections show typical growth of capacity of 10 Mt/year. A significant portion of this plant will be Blast Furnaces built to best global standards; more polluting Blast Furnaces are also expected along with other technologies, notably DRI (Direct Iron Reduction) fired by coal. Coal-fired DRI has significantly higher emissions than a modern Blast Furnace but such 'mini mill' set-ups have allowed many owners to enter the Indian steel sector, a trend encouraged by the Indian government. It would be difficult for the government to assume responsibility for the sector at the present time.

Table 3 shows current status against each of the four currently available abatement categories. The Table identifies potential further policies and support required to incentivise increased abatement and the MRV issues associated with implementation. It should be noted that regulation and other non-financial measures could also support implementation.

### Table 3: Specific policies and measures recommended for India

<table>
<thead>
<tr>
<th>Abatement Category</th>
<th>Existing Policies and Support</th>
<th>Further policies and support</th>
<th>MRV Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The closure of inefficient, highly polluting plant</td>
<td>No policy identified</td>
<td>Assistance to develop policy. Payments could then be made against a defined retirement rate, targeted as appropriate (e.g. welfare to the poor)</td>
<td>Definition of obsolete plant. Verified production figures. Baseline of BAU reduction in production</td>
</tr>
<tr>
<td>2. Improving energy efficiency and carbon efficiency at existing, non-obsolete plant</td>
<td>Some investments being made under Indian policy and CDM. PAT scheme being implemented for large plant. Lack of investment capital</td>
<td>Project-based scheme (e.g. the PAT and/or continuation of CDM). Supplemented by financial support scheme, ideally low cost capital</td>
<td>As per the CDM – baseline, methodology, addiitonality</td>
</tr>
<tr>
<td>3. Ensuring that new plant is built using best available technology</td>
<td>A range of plant types and performance levels continue to be built</td>
<td>Partial investment credit (e.g. low cost capital) if new plant is best available technology. A penalty is indicated against highly-polluting new plant, e.g. tax from a future date</td>
<td>Need to audit plant on its completion. Ideally performance would also be verified at later date(s)</td>
</tr>
<tr>
<td>4. Increasing the use of recycled scrap</td>
<td>India recycling rate low by international standards – expected in a rapidly developing county</td>
<td>Make payments against increased rates of collection made, within India only (to avoid leakage)</td>
<td>Baseline of existing collection rate. Verified quantity collected. Verification sold to and used by Indian steel plant</td>
</tr>
</tbody>
</table>

The study has estimated what these four items may deliver in terms of emission reductions against an arbitrarily set ‘stock turnover’ baseline, whereby emissions are projected on the basis of plant retirement and new build only (i.e. without any specific emission reduction policies). In reality, current Indian policy...
would already move us away from this baseline and it is difficult to estimate what this deviation would actually be. Figure 3 illustrates the results of this calculation. Building new plant to BAT is the dominant source of potential abatement out of a total abatement potential, compared to a baseline of stock turnover, of around 40 MtCO₂ per year from 10 years forward.

Figure 3 India Abatement Potential, relative to a Stock Turnover baseline

![Figure 3](image-url)

Figure 4 shows the impact these ‘Maximum Identified Abatement’ measures would have against a stock turnover baseline. In order to illustrate potential financial flows, it has been assumed that India could receive payment against an ‘Illustrative Sector No Lose Target’ set midway between the stock turnover and maximum identified abatement lines. At a carbon price of $25/tCO₂, illustrative financial flows to India from the sale of credits would be around $0.5bn per year from 10 years onwards.

Figure 4 Improvement in Average Carbon Intensity, 2008-2030 for India Steel sector

![Figure 4](image-url)
What could Sectoral Approaches and Agreements potentially look like?

Given that steel is a large contributor of CO₂ and that it is a largely homogenous product with clear abatement options, it is theoretically a good candidate sector to target for emissions reductions.

Sectoral Approaches and Agreements can take a wide variety of forms; this study has considered the full range. It has rejected the possibility of transnational trading of allowances across the steel sector; this lacks political support. The approaches remaining thus have a national focus. The study has concluded that an approach or agreement which simply passed down a sector target to constituent installations or companies and expected the resultant carbon price to drive abatement would be unlikely to yield significant reductions, since it would be unable to overcome the barriers caused by lack of policy or scarcity of investment capital.

Sectoral Approaches and Agreements should be able to incentivise abatement in China and India against the four categories shown in Tables 2 and 3. The key choice to be made is whether specific approaches should be provided for each of the four abatement categories, or whether a single approach could cover them all. The attraction of the specific approach is that it allows better targeting and limits risk when uncertainty is high as to how much abatement each category could deliver, and at what cost. A single approach would have the advantage of flexibility, allowing reductions to be optimised between categories; its disadvantage is the risk that if one of the categories produced large amounts of reduction, which were subsequently considered to be non-additional, we would see under-abatement from the other categories.

The carbon market could deliver large financial flows. As noted above, a sectoral approach based only on introducing carbon pricing would be unlikely to yield significant abatement: additional policies and measures and/or financial support would be needed to support abatement against the four categories identified. Targets could be set up for the sector as a whole or to incentivise progress against the four abatement categories individually. There is considerable uncertainty as to the levels the baseline and targets would be set at, and considerations would include political as well as technical considerations. In the initial stages, it is unlikely that developing countries would accept targets which would lead to penalty payments if they were not met – they would be likely to insist on Sector No-Lose Targets (SNLT). A degree of uncertainty will be inherent in the setting of baselines and targets, particularly in the early years of the scheme. There is thus a risk that the target could be set too strictly (weakening the incentive to abate) or the target could be set at too lax a level (leading to a windfall gain).

The government would receive any finance from beating the SNLT. In this way, it is hoped that governments would be incentivised to introduce an extended range of policies and measures to reduce emissions from the sector – for example taxes, subsidies, trading schemes, mandatory regulation, policies specific to non price barriers, project based mechanisms with government level liability for performance.

Credits have to achieve a certain degree of MRV (i.e. be measurable, verifiable and reportable). The World Steel Association’s plant level data protocol is a fully developed scheme, which the majority of large plants worldwide are already using. Its use is recommended: it has been developed by the industry itself and the development of an alternative would be likely to take several years.
Conclusions

China and India are already making reductions in their emissions below what would be expected from stock turnover alone. Sectoral Approaches and Agreements could incentivise further reductions. How effective they would be is not yet clear and building up experience on what the steel sector’s abatement potential is, and how abatement can best be incentivised, is necessary.

An effective Sectoral Approach or Agreement would need to overcome both price and non-price barriers. Apportioning a sector target to individual plants and relying on the resultant carbon price alone to drive abatement is unlikely to yield significant reductions in the steel sector. Politically, transnational trading does not appear to be a viable option in at least the medium-term. A national approach, ideally with price and non-price incentives, is thus indicated.

A key part of scheme design is whether it should target a number of individual abatement categories or the sector as a whole. An approach specific to the abatement categories (four currently available categories have been identified in this study) would lower the risks resulting from the considerable uncertainties in abatement costs and potentials and what business-as-usual emissions from the sector would be. But it would be less flexible than a single target for the sector – it would not allow abatement to be optimised across all the sector’s options. This study concludes that there is potential for Sectoral Approaches and Agreements, carefully designed to account for the realities of the steel sector, its abatement options and the state of available information, to incentivise abatement in China and India beyond what they are currently achieving.

Further Work

The steel sector is a key one and it must make progress in controlling its emissions going forward. Sectoral Approaches and Agreements are certainly worthy of further analysis. Further work should focus on better:

- data collection;
- analysis of the available data;
- understanding of the impacts on stakeholders of schemes and their design, based on an analysis of company and organisational structure.

The wider Climate Strategies project on Sectoral Approaches and Agreements aims to meet these needs during 2010. It will develop model agreements, using progressive discussions with stakeholders, in a set of case study countries (India, Japan and China). From these, it will develop a synthesis document.
1 Purpose of this Study

Sectoral approaches and agreements may offer a good option for greenhouse gas (GHG) emission reductions in certain sectors of the economy. In the developing world, they offer the possibility of scaling up from relatively small-scale, project-based emissions reductions. There is a preference, from some countries, for sectoral schemes in the medium term as a pathway towards an ultimate aim of economy-wide emissions reduction targets in developing countries.

To date, work on sectoral approaches and agreements has been dominated by work of a strategic nature, generally focusing on relatively high-level economic and political analysis. The details needed for the successful implementation – both practical and political – have been largely missing. This study is based on the premise that it is essential to understand how decisions – financial and production as well as response to environmental policies - are made within the candidate sectors to better understand what impacts they could have, and at what cost. The study is therefore narrowly focused on:

- the Iron & Steel sector, one of the few sectors where climate policies could significantly increase production costs\(^6\). Steel is a widely-traded commodity (approximately 40% is traded internationally) and thus differential national climate policies could lead to changes in competitiveness and the possible leakage of emissions to countries with less stringent climate policies\(^7\);
- China and India, two non-Annex I countries which are respectively the world’s largest steel producer and the country where highest capacity additions are projected over the medium term.

This study analyses the potential impact of sectoral approaches and agreements, presents what they could look like in practice and provides advice to allow national negotiators to progress the debate on sectoral approaches and agreements within the UNFCCC. It aims to:

- assess the realistic abatement potential within the steel sector, what it might cost and how it could be incentivised;
- gain further insight into the feasibility of different variants on sectoral approaches and agreements in the steel sector, considering the wide range of variants which have been proposed;
- understand the concerns of stakeholders and how these can be answered.

The elements necessary to design and implement Sectoral Approaches and Agreements are analysed and discussed in the following sections. The study concludes by recommending what types, for the steel sector in India and China, would offer the best chance for an international agreement and how effective these may be in reducing GHG emissions.

The work was undertaken by Climate Strategies, a not for profit, academic membership organisation based in Cambridge. The study is the first output of a wider project: further component studies are expected to follow during 2010, so as to build up a broad and fact-based assessment of the issues and options around global sectoral approaches and agreements in steel as part of Climate Strategies’ contribution to the ongoing international debate. The project leader is Peter Wooders, Senior Economist at the International Institute for Sustainable Development (IISD) based in Geneva. Please contact Peter at pwooders@iisd.org to discuss the report or project.

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\(^6\) See Annex A, Figure A7 for an example from the literature showing how carbon costs compare to value added in manufacturing sectors. More examples can be seen in Wooders et al (2009) – see footnote below for full reference.

\(^7\) There is a wide literature on competitiveness and leakage, including the identification of the industrial sectors considered to be at risk. See for example Wooders, P., A. Cosbey, and J. Stephenson (2009) — Border Carbon Adjustment and Free Allowances: Responding to Competitiveness & Leakage Concerns. Round Table on Sustainable Development background paper, OECD, Paris, July 2009, and the Climate Strategies suite of work at [http://www.climatestrategies.org/our-reports/category/32.html](http://www.climatestrategies.org/our-reports/category/32.html).
2 Factual Backdrop

2.1 Sectoral Profile – Economic Output and Carbon Dioxide Emissions

Steel is a ubiquitous product, used across the economy. Worldwide consumption is around 1,300 million tonnes per year, i.e. approximately 0.25 tonnes per world citizen. Steel has a low price elasticity of demand, indicating that it has relatively few substitutes.

The steel sector represents an important part of the economy, particularly in the early stages of industrialisation when a country is growing rapidly. Thus the steel sector is now highly prominent in China and its importance in India is expected to grow rapidly.

Agreements on steel and coal started the creation process of what is now the European Union (EU). Within the EU, steel’s importance in the economy has steadily declined: this pathway has been followed in other developed countries. Its importance politically varies by country, notably depending on whether ownership remains within national hands (e.g. Japan) and on the political strength of organised labour in protecting jobs (e.g. US).

Climate change concerns have significantly increased the prominence of the steel sector. World-wide, the iron and steel sector is currently responsible for 5% of CO₂ emissions from fossil fuel combustion. Upstream mining and transport of iron ore, limestone, coal and other inputs and the downstream transport to market adds to this figure, with life-cycle emissions potentially up to 10% of world CO₂ emissions.

Whatever the exact figure, it is clear that the steel sector is a significant source of world emissions. Steel is produced from iron ore largely by Blast Furnaces (BF). These have been optimised over more than a century of operation, and the potential for energy savings and CO₂ emissions in best available technologies is limited. Recycling scrap, predominantly using electric arc furnaces (EAF), offers a much less energy- and carbon-intensive production route but the percentage of steel recycled is reaching saturation levels. CCS (carbon capture and storage) is a promising future option but it is a pure additional cost (many energy efficiency options reduce operating costs and/or improve product quality) and requires demonstration, the development of associated infrastructure and a regulatory environment and then significant investment. And there is no obvious breakthrough technology which would radically change how steel is made.

Steel technology is ‘locked-in’ to a significant degree, i.e. the performance of new plant built in the at least the medium-term will not deviate significantly from what is available today. This has more in common with the aviation and cement sectors than automobiles or electricity generation, where new technologies could radically reduce greenhouse gas emissions per unit of production.

Projections of GHG emissions show that improvements in carbon intensity are insufficient to offset projected increases in demand for steel. This projects show CO₂ emissions from the iron & steel sector continuing to grow in absolute terms over time. Within a context where the world is looking to reduce its emissions, this would imply steel sector emissions growing as a share of the total. It is far from clear that this is a decision that will ultimately be taken. More aggressive policies on the steel sector, such as carbon taxes or the absolute caps on emissions in place in the EU, must be a possibility going forward.

But steel is a commodity which is widely traded globally. Countries or regions taking unilateral emissions are concerned that their reductions will "leak" in the form of increased production elsewhere, and their loss of income and/or employment. The attractions of a sectoral approach or agreement, if this allowed countries to move together without distorting competitiveness, are clear. A detailed analysis of the key drivers of decision-making for the steel sector has been conducted and is reported in Annex A. Materials and conclusions from this Annex, are used throughout this report.

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8 IEA Online Statistics – 2007 data. Does not include emissions from electricity consumption or the wider life-cycle of upstream and downstream operations.
9 See for example McKinsey and Company (2009), which projects 59% growth in world CO₂ emissions from steel production over the period 2005-30 even if all the abatement options they identify were implemented (see Figures 2.3 and 2.4)
2.2 Steel Production Routes and their Carbon Dioxide Emissions

2.2.1 Three routes of steel production

Figure 2.1 illustrates how steel is produced. There are three main options:

1. The **Blast Furnace (BF)** is the traditional route starting from iron ore. Coke is required, for its energy content, its chemical content (a source of carbon) and for creating the physical structure within the BF to allow the reactions to occur. ‘Pig iron’ (iron with high carbon content, which is very brittle) is produced from the blast furnace, which is then taken to a **Basic Oxygen Furnace (BOF)**; some scrap steel may also be added. The BOF produces molten steel, which is then refined (for example alloying elements are added), cast and finished. The BF/BOF combination is known as an **integrated steel mill**;

2. Starting from scrap only, the use of a BF or DRI can be avoided and an **Electric Arc Furnace (EAF)** only used. Such a **minimill** can be much smaller (and thus have much lower investment cost) than an integrated steel mill;

3. **DRI (Direct Reduced Iron)** is an alternative starting with iron ore. The scale is generally significantly smaller than an integrated steel mill using a BF. Natural gas (if available at a low price) or coal are used to produce reducing gases (carbon monoxide and hydrogen) which are then passed over the iron ore, directly stripping away the oxygen and leaving 'sponge iron' (also known as DRI). This is then taken to an **EAF**, where steel is produced.

2.2.2 Carbon Dioxide Emissions

As a rough rule of thumb:

- Steel from an **integrated mill (BF/BOF)** will typically result in emissions of **1.5-2.5 tCO₂/t steel**, with the lower figures coming from the most advanced, largest plant;
- Starting from scrap steel and using the **EAF-only** route, emissions are typically **0.4 tCO₂/t steel**, i.e. around 20% of those from the BF/BOF route. Emissions are clearly dependent on the source of the electricity consumed (see Figure 2.2);
- **DRI** emissions are lower if they use **natural gas** (approximately **1.1 tCO₂/t steel**) and higher if they use **coal** (approximately **2.5 tCO₂/t steel**).

Figure 2.2 gives more detail, with the ranges showing the difference from using zero-carbon or coal-generated electricity.

2.3 GHG Abatement Options

The key to designing any GHG reduction mechanism, be this a Sectoral Approach (SA) or otherwise, is to understand the options countries have in limiting their GHG emissions. Six categories of options can be identified:

1. The closure of inefficient, highly polluting plant. Such plant tends to be old and small, and may feature obsolete technologies or processes;
2. Improving energy efficiency and carbon efficiency at existing, non-obsolete plant;
3. Ensuring that new plant is built using best available technology;
4. Increasing the use of recycled scrap;
5. Adopting Carbon Capture & Storage (CCS);
6. Developing and implementing breakthrough technologies.

To these could be added demand reduction, either through performance improvement in steels made, by substitution for other products or by pure demand reduction. The option of demand reduction is not considered within the scope of this study, which concentrates on the list of six presented above. Sectoral Approaches and Agreements tend to ignore the possibility of including demand reduction. This ties in with the politics – developing countries are not being asked to agree to demand reductions at present, although it is of course desired by them to become more efficient in the use of materials and energy and this could be
achieved through taxation or other measures. The options available to abate emissions have much in common across the world.\footnote{10}

**Figure 2.1 Steel Production**

**Figure 2.2 Carbon Dioxide Emissions by Steel Production Route (source: IEA ETP 2008)**

\footnote{10} China, with its 40\% of world production, is a key contributor to any world MAC curve
The key points drawn from an analysis of world MAC curves in Box 2.1 are:

- abatement costs for many options could be positive or negative, but that their magnitude is small. As a first approximation, assuming they are zero cost appears reasonable;
- compared to a baseline of average current emissions intensity, options that can be retrofitted to existing plant are only a small fraction of the improvement in abatement we could expect from new plant. It is of key importance that new plant is built to best available technology – but there is no need to incentivise this if it is already happening.

**Box 2.1 World Marginal Abatement Cost curves (MAC)**

A number of studies have estimated world-wide potential reductions using MAC curves (which cover technically feasible options). One of the best known is the work of McKinsey (2007), which illustrates many of the key issues. The curve in Figure 2.3 shows, for the year 2030:

- Total reduction potential of 930 MtCO\(_2\) without CCS, and 1510 MtCO\(_2\) with CCS. Even if all these options were implemented, emissions from the steel sector in 2030 would be 59% higher than in 2005, i.e. an increase from 2.56 GtCO\(_2\) to 4.05 GtCO\(_2\) (see Figure 2.4);
- McKinsey use a social cost construct to assess MACs. This shows negative costs to society from cogeneration and the relatively small contribution identified for replacing coke with charcoal, then relatively low costs (less than €50/tCO\(_2\)) for a whole range of energy efficiency and best available technology (BAT) options. Other studies, based on financial cost measurements, indicate that costs may be higher or lower, but that they tend to be small in magnitude (negative or positive);
- The curve shows that, other than CCS, options that can be retrofitted to existing plant have only a small fraction of the potential associated with options which can be put on new build plant. This demonstrates the importance of locking-in the best possible technology when new plant is built. This is particularly important where capacity growth is projected to be highest (notably in India).

These key trends are confirmed by other studies but precise reduction potential quantities and costs of options remain uncertain. They depend on assumptions and methodologies, notably including where the baseline is set. One of the concepts associated with some Sectoral Approaches and Agreements is that countries should make their "own contribution" in terms of the gaining no credit for negative or low cost options. The uncertainty inherent in formulating MACs shows that there is not likely to be a simple, widely-agreed MAC curve or agreement as to where an "own contribution" level should be set.

The second key issue is the importance of ensuring that new plant is built to the best possible standard (the third of the six key abatement categories identified in Section 2.3). The McKinsey curve indicates that there is widespread potential for building new plant to a better standard than would be expected under BAU (business-as-usual) conditions. The analysis conducted by the Climate Strategies team during this study (see later Sections) does not support this view, suggesting rather that new plant is generally built to high standards in any case (at least in China and, to a lesser extent, in India). This conclusion is a very important one: there is no need to incentivise high standard new build if it is happening already.

A final issue which comes up when considering BAU behaviour and MAC curves is the availability of investment capital. Evidence from the steel sector and others (for example refineries and chemicals) indicate that having energy efficiency and/or carbon reduction options which would payback their investment capital within an acceptable time period does not mean that these options will necessarily be taken up. Anecdotal evidence from the steel industry suggests that, when investment capital is scarce, it will be preferentially invested in new capacity rather than improving performance at existing plants. There thus may be a role for Sectoral Approaches and Agreements to make investment capital available for improvements at existing plant (category 2 in Section 2.3).
2.3.2 Investments made under the CDM (Clean Development Mechanism)

China and India have dominated the CDM in the steel sector, each being responsible for over 100 of the 227 projects either at the validation stage or registered to date. China has a 70% share of the estimated 42.4 MtCO₂/year the projects are expected to generate, compared to India’s 26%. For context, the estimated savings are 3% of the potential reductions McKinsey identify (noting that the basis for comparison is far from equal, with time periods, baselines and country coverage all significantly different).

Waste Heat Recovery (WHR) dominates the expected reductions, accounting for 77% from projects where it is the sole source of emissions reductions and being a part of other projects too. WHR is incorporated into new build as a matter of course.

Four of the most important, and how many times they appear as the key title of a CDM project, are:

1. Coke Dry Quenching (CDQ): 23 times – 20 China, 2 India;
2. Top Gas Recovery Turbine (TRT): 14 times – 12 China, 2 India;
3. Coke Oven Gas (COG) use for Power Generation: 14 times, all China;
4. Blast Furnace Gas (COG) use for Power Generation: 18 times - 13 China, 3 India.

It is clear that China has dominated the use of CDM for these options. They can lead to major emissions reductions: average reductions are between 100,000 and 400,000 tCO₂/year per plant for the technologies. If we assume that an average plant is producing of the order of 2 Mtpa of steel and emitting 4 MtCO₂/year, the technologies can therefore each save 2.5-10% of emissions on average.
COG and BFG are standard technologies at plants in developed countries. CDQ is standard in Japan but not in certain other developed countries. It is understood that all new Chinese Blast Furnace plant must now recover COG and BFG for power generation and include CDQ technology. The CDM is thus useful to assess what can be done at existing plant but is not necessarily a good guide for new build. Details of the analysis conducted on the CDM are included in Annex A4.

2.3.3 Abatement Potential, Cost and Value in China

Annex A5 reviews Chinese production, policy and plans. The available information allows a number of conclusions to be drawn on what type of emission abatement options are available. It allows some calculations to be made on what quantity these options may deliver but a number of assumptions must be made: there is no definitive projection of business as usual emissions or an understanding of what Chinese policy and plans may deliver.

The analysis now presented attempts to quantify abatement quantities and costs from the available information. It makes projections of how the intensity of steel sector emissions in China could develop over the period to 2030 and what the value of carbon saved could be relative to business as usual.

The analysis and calculations now presented have an illustrative nature and illuminate many interesting points. The calculations could be improved by further work and better data but would still exhibit significant uncertainties. This is an important conclusion: at the present time, setting definite targets for individual abatement options (e.g. the retirement of obsolete plant) or for the steel sector as a whole will necessarily involve major uncertainties. Building up data sets and experience will reduce this uncertainty, but this is likely to take several years to realise.

Projected Steel Production

IEA (2009) projections for ‘low’ and ‘high’ production scenarios are shown in Figure 2.5. Growth is slow, with production is 2030 between 585 and 658 Mt, compared to 500.5 Mt in 2008.

Figure 2.5  Projected steel production in China, 2008-2030

Stock Model Assumptions

A simple stock model has been created to investigate how emissions projections vary with new build and retirement of plant and improvements to plant performance. Table 2.1 shows the assumptions made – these are drawn from the data and analysis shown in Annex A5. Shares of production and emission factors
have been calibrated to an average intensity of 2.13 tCO₂/t steel.¹¹ Studies show a wide range of average intensity figures for recent years; one source of difference is whether, and how, emissions from electricity consumption are accounted for. This illustrates the uncertainty inherent in currently available data. It is not considered to be a serious weakness for the analysis now presented, which seeks to show how the relative intensity of emissions changes.

The key assumptions which have been made for the calibration are:

- there is 100 Mt produced from obsolete plant, 250 Mt from non-obsolete (but not modern) plant and 45 Mt (9%) from EAF. Modern Blast Furnaces (BF) are assumed to account for the residue;
- scrap recycling rates are assumed to increase by 0.5% of total production per year. This projection could be improved with further analysis;²²
- the intensity of modern BF is assumed to be 1.8 tCO₂/t steel, corresponding to global best available technology. Evidence points to new plant in China being built to this standard. It is assumed that the intensity applies unchanged for the whole period to 2030 – in practice, we could expect some (limited) improvement over time;
- the intensity of obsolete plant has been set at an average of 3.1 tCO₂/t steel to balance the calibration;
- business-as-usual retirement is projected to be linear over 40 years for non-obsolete existing plant and linear over 20 years for obsolete plant.

Table 2.1  Stock Model Assumptions for China

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Production Mt, 2008</th>
<th>Intensity tCO₂/t steel</th>
<th>BAU Retire. Rate, %/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern BF</td>
<td>104.95</td>
<td>1.80</td>
<td>0.0%</td>
</tr>
<tr>
<td>Non-Obsolete</td>
<td>250.00</td>
<td>2.20</td>
<td>2.5%</td>
</tr>
<tr>
<td>Obsolete Plant</td>
<td>100.00</td>
<td>3.10</td>
<td>5.0%</td>
</tr>
<tr>
<td>EAF</td>
<td>45.55</td>
<td>0.40</td>
<td>0.0%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>500.50</td>
<td>2.13</td>
<td></td>
</tr>
</tbody>
</table>

**Improvement in Carbon Intensity due to Stock Turnover**

How the average emissions intensity varies due only to stock turnover (i.e. without specific policy to reduce emissions) is important to understand. Based on the projected production in Figure 2.5 and assumptions made in Table 2.1, Figure 2.6 shows how the average intensity improves in the period to 2030. Average intensity improves by the order of 1% per year due to stock turnover, with relatively minor differences depending on whether the IEA low or high projection (or an average of these) is used.

A projection of emissions driven by stock turnover is one possibility for setting “BAU” (business as usual). It is somewhat theoretical and pessimistic, being based on China enacting no emission reduction policies in the future. China’s currently stated policy would be expected to reduce emissions below this projection.

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¹¹ The intensity has been derived from a Tsinghua University 2009 study which stated Chinese emissions in 2006 were 900 MtCO₂ and a World Steel Association production figure of 422.6 Mt steel in 2006.

²² McKinsey project an increase in recycling from 70 Mt currently to 290 Mt in 2030. This extra recycling would essentially make up all the extra capacity required in China and appears over-optimistic.
Figure 2.6 Improvement in Average Carbon Intensity due to Stock Turnover

Emission Reduction Potential compared to Stock Turnover
The four currently-available categories of abatement have been modelled as follows:

1. The closure of inefficient, highly polluting plant. It is assumed that policy could reduce the retirement period to 10 years (10% per year) from 20 years (5% per year) under business as usual conditions;
2. Improving energy efficiency and carbon efficiency at existing, non-obsolete plant. It is assumed that a 0.2 tCO₂/t steel improvement can be made for 150 Mt of existing, non-obsolete capacity;
3. Ensuring that new plant is built using best available technology. There is little evidence that new plant could be built to higher standards. An assumption has been made that an improvement in the average of 0.1 tCO₂/t steel would be achievable;
4. Increasing the use of recycled scrap. It is assumed that policy could increase the recycling by a further 0.5% of production per year.

The results obtained are shown in Figure 2.7. A total of 150 MtCO₂ emission reductions are projected within 10 years, and these could then be maintained. In the initial years, the early retirement of obsolete plant is the key contributor to emissions abatement. In later years, increased scrap recycling becomes the dominant factor. These estimates are based on many assumptions and are little more than indicative. What they do indicate is that increasing scrap recycling is likely to be a key issue – how this can be incentivised by policy is not clear.

The Figure shows an improvement against pure stock turnover. This should not be confused with an improvement against business as usual – as stated above, Chinese policy already includes a range of measures to reduce emissions compared to business as usual. It could be argued that some or all of the potential improvements in emissions beyond stock turnover are already included in Chinese policy; it is not easy to work out either the expected impact of stated policies in terms of their emissions improvement nor is stated policy necessarily a good indicator of the baseline which would be agreed under an international climate change agreement.
Abatement Costs
The literature reviewed in Annex A does not give a clear indicator as to what the costs of abatement would be. The conclusion drawn in this study is that abatement costs are around zero, with other barriers (such as scarcity of investment capital or lack of regulation) stopping the uptake of the measures. Thus no costs are attributed to the steel industry in meeting the emission reductions shown in Figure 2.7.

Value of Carbon Saved compared to Stock Turnover
Based on a carbon price of $25/tCO₂, Figure 2.8 shows that the value of carbon saved compared to a stock turnover baseline would build up to between $3.5 and 4.0 billion per year from 10 years in the future. With different carbon prices, the figures can be simply pro-rated. Considerations of how abatement could be financed using Sectoral Approaches and Agreements are discussed in Section 3.

Again it is important to point out that this value is set against a baseline of pure stock turnover and that stated Chinese policy would realise some or all of the savings.
Improvement in Average Carbon Intensity

Figures 2.9a and 2.9b show how the full implementation of the four abatement options would improve average carbon intensity against a baseline of pure stock turnover. The improvement rises steadily to around 10% within 10 years and then holds steady thereafter.

In the Figures, a “Sector No Lose Target” level has been arbitrarily set at the mid-point between the stock turnover and maximum identified abatement lines. Where the “Sector No Lose Target” should be set, and indeed the “BAU” baseline, require a level of certainty that we do not currently have. Setting the lines at the moment would be at least partially based on political, rather than technical, considerations.

The Figure shows potential, it does not show what a sectoral crediting mechanism or other sectoral target measure might achieve. If the target were set at the “Sector No Lose Target” level, and the sector achieved emission reductions to the “Maximum Identified Abatement”, then credits of 50% of the value showed in Figure 2.8 would be obtained by the sector.

Figure 2.9a Improvement in Average Carbon Intensity, 2008-2030

![Figure 2.9a](image)

Figure 2.9b Improvement in Average Carbon Intensity, 2008-2030

![Figure 2.9b](image)
Extra Potential Reductions from Carbon Capture and Storage and Breakthrough Technologies

CCS is unlikely to be implemented significantly before 2020. Annex A5 shows that certain estimates show that CCS may realise a further 300 MtCO₂ of reductions in the future. No estimates have been made for how much abatement could be realised from (currently unspecified) breakthrough technologies.

2.3.4 Abatement Potential, Cost and Value in India

Annex A6 reviews Indian production, policy and plans. Similarly to the Chinese analysis presented in the preceding section, the analysis has an illustrative nature. Uncertainties are higher in India than in China: the sector is more diverse in terms of ownership and technology, Indian policy is not as well-developed and Indian output is expected to grow more strongly in relative terms.

Projected Steel Production

IEA (2009) projections for ‘low’ and ‘high’ production scenarios are shown in Figure 2.5. Growth is rapid, with projected production is 2030 between up to five times the 55.2 Mt produced in 2008.

Figure 2.10  Projected steel production in India, 2008-2030

Stock Model Assumptions

A simple stock model has been created to investigate how emissions projections vary with new build and retirement of plant and improvements to plant performance. Table 2.2 shows the assumptions made – these are drawn from the data and analysis shown in Annex A6. Shares of production and emission factors have been calibrated to an average intensity of 2.34 tCO₂/t steel.¹³ Studies show a wide range of average intensity figures for recent years; one source of difference is whether, and how, emissions from electricity consumption are accounted for. This illustrates the uncertainty inherent in currently available data. It is not considered to be a serious weakness for the analysis now presented, which seeks to show how the relative intensity of emissions changes.

The key assumptions which have been made for the calibration are:

- Natural gas-fired DRI and EAF figures are taken from Sreenivasamurthy (2008). This study identifies 26.4 Mt BF and 14.0 Mt Coal DRI: these capacities have been apportioned to calibrate to the average sector intensity. Further work could improve these assumptions;
- Annex A6 details Indian plans that 57% of new capacity will be (modern) Blast Furnace, 30% Coal DRI, 3% Natural Gas DRI and 10% EAF. These ratios have been applied to all new build throughout the period to 2030;
- the intensity of modern BF is assumed to be 1.8 tCO₂/t steel, corresponding to global best available technology. Evidence points to at least some new plant in India being built to this standard. It is

¹³ This average intensity is based on analysis from Sreenivasamurthy (2008), itself based on Ministry of Steel date for 2007/08.
assumed that the intensity applies unchanged for the whole period to 2030 – in practice, we could expect some (limited) improvement over time;

- the intensity of obsolete plant has been set at an average of 3.6 tCO\textsubscript{2}/t steel to balance the calibration;
- business-as-usual retirement is projected to be linear over 40 years for non-obsolete existing plant and linear over 20 years for obsolete plant.

Table 2.2 Stock Model Assumptions for India

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Production Mt, 2008</th>
<th>Intensity tCO\textsubscript{2}/t steel</th>
<th>BAU Retire. Rate, %/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern BF</td>
<td>1.73</td>
<td>1.80</td>
<td>0.0%</td>
</tr>
<tr>
<td>Non-Obsolete BF</td>
<td>15.00</td>
<td>2.50</td>
<td>2.5%</td>
</tr>
<tr>
<td>Natural Gas DRI</td>
<td>5.93</td>
<td>1.10</td>
<td>2.5%</td>
</tr>
<tr>
<td>Coal DRI</td>
<td>10.00</td>
<td>2.50</td>
<td>2.5%</td>
</tr>
<tr>
<td>Obsolete Plant (all types)</td>
<td>15.00</td>
<td>3.60</td>
<td>5.0%</td>
</tr>
<tr>
<td>EAF (all scrap use)</td>
<td>7.55</td>
<td>0.40</td>
<td>0.0%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>55.20</strong></td>
<td><strong>2.34</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Improvement in Carbon Intensity due to Stock Turnover**

How the average emissions intensity varies due only to stock turnover (i.e. without specific policy to reduce emissions) is important to understand. Based on the projected production in Figure 2.10 and assumptions made in Table 2.2, Figure 2.11 shows how the average intensity improves in the period to 2030. Average intensity improves by the order of 1% per year due to stock turnover, with relatively minor differences depending on whether the IEA low or high projection (or an average of these) is used.

A projection of emissions driven by stock turnover is one possibility for setting “BAU” (business as usual). It is somewhat theoretical and pessimistic, being based on China enacting no emission reduction policies in the future. China’s currently stated policy would be expected to reduce emissions below this projection.

**Figure 2.11 Improvement in Average Carbon Intensity due to Stock Turnover**

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**Emission Reduction Potential compared to Stock Turnover**

The four currently-available categories of abatement have been modelled as follows:

1. *The closure of inefficient, highly polluting plant.* It is assumed that policy could reduce the retirement period to 10 years (10% per year) from 20 years (5% per year) under business as usual conditions;
2. Improving energy efficiency and carbon efficiency at existing, non-obsolete plant. It is assumed that a 0.2 tCO₂/t steel improvement can be made for 10 Mt of existing, non-obsolete capacity;

3. Ensuring that new plant is built using best available technology. There is some evidence that new Blast Furnaces could be built to higher standards. An assumption has been made that an improvement in the average of 0.2 tCO₂/t steel would be achievable for Blast Furnaces. 30% of new capacity is projected to be Coal DRI. It is assumed that half of this capacity could be built as Blast Furnaces, with a 0.7 tCO₂/t steel reduction in emissions;

4. Increasing the use of recycled scrap. It is assumed that policy could increase the recycling by a further 0.5% of production per year.

The results obtained are shown in Figure 2.11. A total of 35 MtCO₂ emission reductions are projected within 10 years, rising to 45 MtCO₂ in a further 10 years. The retirement of obsolete plant is a key contributor in the early years, with building new plant to best available technology then dominating. This is to be expected in a country such as India where capacity is projected to grow strongly.

The Figure shows an improvement against pure stock turnover. This should not be confused with an improvement against business as usual – as stated above, Indian policy already includes a range of measures to reduce emissions compared to business as usual. It could be argued that some or all of the potential improvements in emissions beyond stock turnover are already included in Indian policy; it is not easy to work out either the expected impact of stated policies in terms of their emissions improvement nor is stated policy necessarily a good indicator of the baseline which would be agreed under an international climate change agreement.

Figure 2.11 Potential Improvement in Emissions beyond Stock Turnover

![Figure 2.11 Potential Improvement in Emissions beyond Stock Turnover](image)

**Abatement Costs**

The literature reviewed in Annex A does not give a clear indicator as to what the costs of abatement would be. The conclusion drawn in this study is that abatement costs are around zero, with other barriers stopping the uptake of the measures. Thus no costs are attributed to the steel industry in meeting the emission reductions shown in Figure 2.11.

**Value of Carbon Saved compared to Stock Turnover**

Based on a carbon price of $25/tCO₂, Figure 2.12 shows that the value of carbon saved compared to a stock turnover baseline would build up to around $1 billion per year. With different carbon prices, the figures can be simply pro-rated. Considerations of how abatement could be financed using Sectoral Approaches and Agreements are discussed in Section 3.

Again it is important to point out that this value is set against a baseline of pure stock turnover and that stated Indian policy would realise some or all of the savings.
Improvement in Average Carbon Intensity

Figures 2.13a and 2.13b show how the full implementation of the four abatement options would improve average carbon intensity against a baseline of pure stock turnover. The improvement rises steadily to around 10% within 10 years and then holds steady thereafter.

In the Figures, a “Sector No Lose Target” level has been arbitrarily set at the mid-point between the stock turnover and maximum identified abatement lines. Where the “Sector No Lose Target” should be set, and indeed the “BAU” baseline, require a level of certainty that we do not currently have. Setting the lines at the moment would be at least partially based on political, rather than technical, considerations.

The Figure shows potential, it does not show what a sectoral crediting mechanism or other sectoral target measure might achieve. If the target were set at the “Sector No Lose Target” level, and the sector achieved emission reductions to the “Maximum Identified Abatement”, then credits of 50% of the value showed in Figure 2.12 would be obtained by the sector.

Figure 2.13a  Improvement in Average Carbon Intensity, 2008-2030
Extra Potential Reductions from Carbon Capture and Storage and Breakthrough Technologies

CCS is unlikely to be implemented significantly before 2020. There has been little discussion as to the potential of CCS in India (see Annex A6); indeed, many public statements are firmly against the technology. No estimates have been made for how much abatement could be realised from (currently unspecified) breakthrough technologies.

2.4 Sector Boundaries

2.4.1 World Steel Association Data Collection Project

The World Steel Association (WSA) initiated a CO₂ emissions data collection project in 2007 (see http://www.worldsteel.org/climatechange/files/2/2/Data%20collection%20user%20guide.pdf). The project envisages collecting data on a plant-by-plant basis, in support of the WSA’s proposal to reduce steel-related greenhouse gas emissions through a global solution. The use of the protocol is now widespread.¹⁴

The WSA’s methodology appears to be the only fully-developed, currently available option: it has widespread support (for example from Japanese producers), and the WSA membership includes almost all major producers across the world (including China). It includes a detailed description of what to measure and how to measure it, including default emission factors. Figure 2.15 summarises the system boundaries.¹⁵

The WSA approach is considered to be the only protocol which could be used in the short-term. The use of an alternative would need to gain acceptance from steel producers. It would need to show advantages over the current proposal. The development of an alternative would be likely to take several years.

¹⁴ In November 2008, the WSA reported that, ‘More than 56 member companies have provided data to the WSA, representing more than 178 sites. The information collected accounts for 32 percent of global steel production and 60 percent of WSA member production. The WSA hopes to receive information from 75 percent of its members by the end of the year.’ ‘It is our intention that once the data is collected and verified, there will be reporting on a national or regional basis by the steel industry all around the world,” says World Steel Association Director General Ian Christmas. “Over time we hope to show real progress by the industry in reducing our carbon dioxide emissions for every ton of steel we produce. It is also intended that this process will enable steel companies and national and regional associations to establish targets for future commitments to reduce specific emissions.’

¹⁵ (a) A plant basis is used; (b) The unit of production is a tonne of crude steel; (c) On-site power generation is included; (d) Scope 1, Scope 2 and Scope 3 emissions are all part of the boundary: these refer to GHG protocols and are direct emissions from fossil fuel combustion (1), upstream electricity and steam brought into the site (2) and exports of BF and BOF gas (3) respectively. This methodology is inconsistent with the direct emissions-only approach used in schemes such as the EU ETS; (e) The “credit” item refers to downstream credit from the use of slag (from BF and BOF) in the cement sector. At present, this credit all falls to the cement sector (or to concrete use).
2.4.2 Issues with the System Boundary

The WSA methodology treats on-site and imported electricity equally and thus there is no leakage issue. There is always an issue as to what an appropriate emission factor for imported electricity should be, but an appropriate protocol can be set. This may require a change to the WSA’s current approach.

The steel sector claiming credit for slag used for cement substitution has not been accepted as a principle by the cement sector or by policymakers more widely. Downstream customers have held the market power to date. It is considered that this has contributed to them being able to claim credit for emission reductions. There is little to suggest that the balance of market power is changing, despite the consolidation of the steel sector in many countries and regions.

Two issues could distort the signals Sectoral Approaches and Agreements give to sites to reduce their emissions:

1. **Scrap.** Increasing the use of scrap, either in a BOF or by adding EAF capacity, can significantly reduce emissions per tonne of final production. If this scrap is from additional collection, there is no problem. If it is a redirection of scrap which would have been used elsewhere, then there are no real reductions (rather, we have a case of scrap, and emissions, leakage);
2. **Coke.** Importing coke onto a site rather than producing it within coke ovens has a significant emissions benefit to the site. Again it is essential to look at the market and assess the potential for leakage.
These two issues are discussed in detail in Annex A7 and Annex A8. There are similarities with work on consumption-based carbon accounting as an alternative to production-based systems. There is clearly potential for leakage from changes in scrap and coke trade, but currently no empirical evidence to suggest whether, and how large, such effects could be.

### 2.5 Measuring, Reporting and Verifying (MRV)

Current MRV experience revolves largely around the EU ETS, the CDM and the WSA data collection project. In all these cases, data is collected on a site rather than sector level.

Sectoral level data is collated in many nations, for the purposes of voluntary sectoral targets (see for example Japan and the UK) or for analysing trends. Such data tends to include relatively few data points and may not stand up to rigorous MRV. It is important to note that the data is essentially a compilation of data from individual plants.

For large companies and plants, the WSA’s data collection project sets a protocol which has been widely discussed and optimised. In addition, many large plants are already required to provide data to their national authorities on fuel and electricity consumption, output, etc. It is the small plants, notably the very smallest, where data is least available currently and where generating data in the future will be most problematic.

If a Sectoral Approach or Agreement were to require the collection of financial data (for instance a company’s value added in order to set a target on the basis of CO₂ emissions per unit of GDP), this could be challenging. Such data is not generally collated on a sectoral level and would carry anti-trust and commercial confidentiality issues. Even data which has a physical basis leads to important confidentiality and anti-trust issues – experience from the Cement Sustainability Initiative (CSI) shows that there need to be strict rules governing who has access to data and what level of disaggregation data can be reported at.

For physical data, from large plants, there does not appear to be any reason why a good data set cannot be generated within a reasonably short time period (no more than 3 years).

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See for example the DFID work commissioned from the SEI and University of York.
3 Sectoral Approaches and Agreements: Design Types for Steel in China and India

The analysis is Section 2 concentrated on establishing the factual background of the sector – the driver of why it makes its decisions – and the GHG abatement options available to it. This Section uses this analysis to look at analyse the design features a Sectoral Approach or Agreement could contain, using these as a toolkit in order to reach a view on the mechanisms that could be employed within the steel sector. It looks at how these mechanisms could be developed over time, taking into account their purposes:

1. to reduce emissions from the sector;
2. to allow financial transfers to be made from developed to developing countries, an essential component of a UNFCCC deal;
3. to act as a step towards global carbon trading;
4. to reduce competitiveness and leakage impacts.

The analysis in Section 2 concentrated on the first of these – the sector’s potential to reduce its GHG emissions. It found that there were six areas where emissions could be abated, in addition to reduction in demand. How current Chinese and Indian policies and support relate to these six categories is shown in Table 3.1.

Table 3.1 Steel Sector Abatement Categories and Chinese and Indian policies and support

<table>
<thead>
<tr>
<th>Abatement Category</th>
<th>China - Policies and Support</th>
<th>India - Policies and Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The closure of inefficient, highly polluting plant</td>
<td>Government already has policy in place. Unclear what a Sectoral Approach might add</td>
<td>No explicit comment in policy</td>
</tr>
<tr>
<td>2. Improving energy efficiency and carbon efficiency</td>
<td>Investment capital is scarce(^{17}) for energy efficiency improvements</td>
<td>Investment capital is scarce(^{18}) for energy efficiency improvements</td>
</tr>
<tr>
<td>and carbon efficiency at existing, non-obsolete plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ensuring that new plant is built using best available technology</td>
<td>New Chinese plant is already specified to meet BAT</td>
<td>New Indian plant expected to meet BAT in many cases</td>
</tr>
<tr>
<td>4. Increasing the use of recycled scrap</td>
<td>General desire without explicit policy</td>
<td>General desire without explicit policy</td>
</tr>
<tr>
<td>5. Adopting Carbon Capture &amp; Storage (CCS)</td>
<td>No explicit policy</td>
<td>No explicit policy. Certain commentators against using the option in India</td>
</tr>
<tr>
<td>6. Developing and implementing breakthrough technologies</td>
<td>No explicit policy</td>
<td>No explicit policy</td>
</tr>
</tbody>
</table>

It should also be borne in mind that there are other options to reduce emissions than Sectoral Approaches and Agreements, including taxation and the NAMAs under discussion within the UNFCCC. If Sectoral Approaches and Agreements are shown to be complex and have uncertain impacts on abatement, we should consider that an alternative policy may be preferable. The politics are clearly important. It might be shown that a global carbon price would be the most efficient policy but there are significant barriers to its implementation. One way of assessing Sectoral Approaches and Agreements is how they perform compared to a carbon price.

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\(^{17}\) This conclusion is based on anecdotal evidence, albeit from a range of respondents and countries. It is worthy of further, empirical work.

\(^{18}\) As above.
3.1 Specific policies and measures for each of the ‘bottom up’ abatement categories

Any sectoral approach or agreement should incentivise extra abatement within the categories presented in Table 3.1. This study concentrates on the first four of these categories, i.e. those that are currently available.

Sectoral approaches based on such ‘bottom up’ considerations tend to be favoured by the industry. The APP (Asia-Pacific Partnership) is a proponent, as is the Indian steel industry (through the PAT scheme, which features targeted reductions from individual plants following an energy audit) and the World Steel Association – its GSSA for the post-2012 period in shown in Box 3.1. While transnational in scope, the WSA proposal does not require countries to trade allowances against national caps (which was discounted above as having inadequate political support).

Box 3.1 WSA Proposal for a Global Steel Sector Approach, post-2012

The global problem of climate change requires a global solution. Policies to encourage improved energy efficiency and reduced CO₂ emissions are important in all regions. The steel industry is asking for a new emissions regulatory regime that takes a global steel sector approach, is intensity based, verifiable and finally is technology driven. The industry is asking that:

1. Governments should work closely with the steel industry on a global approach by adopting a sector specific framework which involves all major steel-producing countries.
2. Any emission regulatory regimes should support the expansion of efficient steel companies and the decline of the least efficient companies based on an equal basis.
3. Governments should work with worldsteel to adopt and support a new methodology that will measure and analyse emissions data from its member companies’ plants in all major steel producing countries.
4. Governments should work with the steel industry to invest in the next generation of breakthrough technology CO₂ programmes, to bring about the next major advancement in steelmaking.

3.1.1 Specific Policies and Measures for China and India

Tables 3.2 and 3.3 show potential policies and measures for the four currently available abatement categories, for China and India. The current status of policy and support is detailed, as are the measuring, reporting and verifying (MRV) issues which would need to be overcome.

Specific policies are readily identifiable for each of the abatement categories. There are some differences between China and India, notably due to the relative level of policy implementation and to the type of plant that are currently being built (Indian plant is much more varied than that of China).

A Note on Energy Efficiency Targets

Energy efficiency targets are favoured by a number of countries, including Japan and India (for example the PAT scheme). They also fit into the way that China tends to consider the benefits of options which both reduce energy consumption and emissions.

Economically, energy efficiency targets are only an indirect method for carbon reduction and are hence less economically efficient in meeting carbon targets. They may encourage some perverse behaviour, depending on scheme design. They are most suitable for an initial step aiming primarily at building up developing countries’ capacity.

Longer term abatement: Carbon capture and storage (CCS) and Breakthrough technologies

Excluding demand reduction, only CCS and/or breakthrough technologies could reduce CO₂ emissions from the steel sector such that world absolute emissions would not increase going forward. Both options are of

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international interest and current carbon prices only partially incentivise their development and deployment. Neither option is expected to have much impact until the longer term (e.g. 15 years+). Wide international co-operation is indicated for both options.

Table 3.2 Specific policies and measures recommended for China

<table>
<thead>
<tr>
<th>Abatement Category</th>
<th>Existing policies and support</th>
<th>Further policies and support</th>
<th>MRV Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The closure of inefficient, highly polluting plant</td>
<td>China already implementing policy</td>
<td>Make payments based on faster reduction in production than current policy</td>
<td>Definition of obsolete plant. Verified production figures. Baseline of planned reduction in production</td>
</tr>
<tr>
<td>2. Improving energy efficiency and carbon efficiency at existing, non-obsolescent plant</td>
<td>Some investments being made under Chinese policy and CDM. Lack of investment capital</td>
<td>Project-based scheme (e.g. continuation of CDM). Supplemented by financial support scheme, ideally low cost capital</td>
<td>As per the CDM – baseline, methodology, additionality</td>
</tr>
<tr>
<td>3. Ensuring that new plant is built using best available technology</td>
<td>Believed that China is already building to best global standard</td>
<td>Consider partial investment credit (e.g. low cost capital) if new plant is best available technology</td>
<td>Need to audit plant on its completion. Ideally performance would also be verified at later date(s)</td>
</tr>
<tr>
<td>4. Increasing the use of recycled scrap</td>
<td>China recycling rate low by international standards – expected in a rapidly developing country</td>
<td>Make payments against increased rates of collection made, within China only (to avoid leakage)</td>
<td>Baseline of existing collection rate. Verified quantity collected. Verification sold to and used by Chinese steel plant</td>
</tr>
</tbody>
</table>

Table 3.3 Specific policies and measures recommended for India

<table>
<thead>
<tr>
<th>Abatement Category</th>
<th>Existing Policies and Support</th>
<th>Further policies and support</th>
<th>MRV Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The closure of inefficient, highly polluting plant</td>
<td>No policy identified</td>
<td>Assistance to develop policy. Payments could then be made against a defined retirement rate, targeted as appropriate (e.g. welfare to the poor)</td>
<td>Definition of obsolete plant. Verified production figures. Baseline of BAU reduction in production</td>
</tr>
<tr>
<td>2. Improving energy efficiency and carbon efficiency at existing, non-obsolescent plant</td>
<td>Some investments being made under Indian policy and CDM. PAT scheme being implemented for large plant. Lack of investment capital</td>
<td>Project-based scheme (e.g. the PAT and/or continuation of CDM). Supplemented by financial support scheme, ideally low cost capital</td>
<td>As per the CDM – baseline, methodology, additionality</td>
</tr>
</tbody>
</table>

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20 See for example the European Commission’s "ULCOS" project, which has been operational for over 5 years and is now moving onto demonstration projects costing over $100m each. The experience of the Aviation sector is also instructive.

21 Note that this option is potentially very expensive and may not yield significant carbon emission reductions

22 India’s ‘Perform, Achieve and Trade’ scheme will apply to major emitters in power, rail and industry. Plants will be audited and then agree targets against which they can trade, on the basis of carbon or energy, absolute or intensity.
3. Ensuring that new plant is built using best available technology

A range of plant types and performance levels continue to be built. Partial investment credit (e.g. low cost capital) if new plant is best available technology. A penalty is indicated against highly-polluting new plant, e.g. tax from a future date. Need to audit plant on its completion. Ideally performance would also be verified at later date(s).

4. Increasing the use of recycled scrap

India recycling rate low by international standards – expected in a rapidly developing country. Make payments against increased rates of collection made, within India only (to avoid leakage). Baseline of existing collection rate. Verified quantity collected. Verification sold to and used by Indian steel plant.

### 3.1.2 Potential Costs and Impacts of Specific Policies and Measures

**Abatement Category 2: Improving energy efficiency and carbon efficiency at existing, non-obsolete plant.**

This study has concluded that there is no conclusive evidence showing that carbon-intensity improvements are positive or negative cost. It also argues that the key barrier is typically the difficulty in sourcing the initial investment capital.

The calculations in Table 3.4 assume that 10% of the existing plant which would not be upgraded under business-as-usual could be invested in, if an appropriate incentive were found. Using a series of illustrative assumptions, it shows that emissions could be reduced by a further 3 MtCO₂/year in China and 0.2 MtCO₂/year in India each year. This would require investment incentives of up to $230 million per year and $15 million per year in China and India respectively.

**Table 3.4 Illustrative calculation of cost of incentivising efficiency at existing plant**

<table>
<thead>
<tr>
<th>Country</th>
<th>Current Production, Mt</th>
<th>Annual Upgrade Rate (%/yr)</th>
<th>Emission Reductions (tCO₂/t steel)</th>
<th>Emission Reductions (MtCO₂/yr)</th>
<th>Required Investment Capital ($m/yr)</th>
<th>Required Investment Incentive ($m/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>150</td>
<td>10%</td>
<td>0.2</td>
<td>3</td>
<td>460</td>
<td>230</td>
</tr>
<tr>
<td>India</td>
<td>10</td>
<td>10%</td>
<td>0.2</td>
<td>0.2</td>
<td>30</td>
<td>15</td>
</tr>
</tbody>
</table>

**Abatement Category 3: Ensuring that new plant is built using best available technology**

Projected capacity expansion is of the order of 6 Mt/year in China. The vast majority is expected to be Blast Furnaces. At a typical investment cost of $700/t steel capacity, this implies annual investment of the order of $4 billion/year. It has been previously stated that Chinese new plant is already built to high standards. Emission reductions from contributing to new plant investment costs may thus achieve little, at high cost. If external investment could reduce emissions by an average of 0.1 tCO₂/t steel, this would be considered to be significant. If a 10% contribution to investment were made, this would require a financial flow of $400 m/year. Total resultant emissions reductions of 0.6 MtCO₂/year for a $400 m/year investment must be considered expensive: at a carbon price of $25/tCO₂, the carbon value saved per year would be $15 m/yr, giving a simple payback of over 25 years.

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Note that this option is potentially very expensive and may not yield significant carbon emission reductions.

Again, this is based on anecdotal, rather than empirical, evidence.

Nominal emissions improvement for a non-modern Blast Furnace.

Levelised capital payment assuming break-even is at 10% real discount rate over 10 years, with a carbon price of $25/tCO₂.

Assuming a 50% reduction in capital cost would be required (in the form of a grant, lower interest rate, interest holiday, etc.)

Lower than the 250 Mt of total capacity shown in Table 2.1 due to the progressive retirement of some of this capacity.

See first table in this section, which shows production increasing from 500.5 Mt/yr in 2008 to 622 Mt/yr in 2030.
The economics in India are more favourable for two reasons:

a. Some of the Blast Furnaces being built are not to best global standards;
b. Other technologies are also built, some of which to significantly lower emission standards (notably coal-fired DRI).

We could envisage reductions in average emissions of 0.2 tCO₂/t steel and 0.7 tCO₂/t steel respectively from the two options. The table below summarises potential financial flows for these two options, assuming that BAT BF could contributed an extra 2 Mt/yr of new capacity and that 1 Mt/yr of Coal DRI could be redirected into BAT BF, within a total of approximately 10 Mt/yr new build. With a 10% contribution to initial investment cost, building high efficiency rather than low efficiency Blast Furnaces would cost $140 million per year and yield 0.4 MtCO₂ per year of emissions reductions. It is assumed that a 25% contribution would be needed to move away from DRI, giving an annual total investment incentive of $200 million for 0.7 MtCO₂/yr reductions. These figures are clearly highly uncertain and practical compensation mechanisms that gave a financial stake in the large new Blast Furnaces built to those who had not built smaller DRI plant appear to be very challenging to design.

An important principle which arises is whether it is sensible to provide incentives for the building of new steel capacity. Steel is a carbon-intensive process and steel production would be expected to decrease within a lower CO₂ emissions future. 'Taxing the bads' seems a more logical response and an alternative policy would be for India to make the building of highly-polluting plants less attractive. One way would simply be to regulate against them but this would be a blunt instrument. A potential alternative would be to announce that a carbon tax would be applied to highly-polluting plant, perhaps phased in over a period. At $25/tCO₂, the resultant tax level compared to a baseline of best available Blast Furnace technology would be $5/t steel for the lower efficiency Blast Furnace and $18/t steel for a coal-fired DRI plant. Such a tax could be levied in advance to act as a disincentive to the original investment. For a low efficiency 1.5 Mt/year capacity Blast Furnace emitting 0.2 tCO₂steel more than the best available technology, the tax would be $7.5 million per year, or $75 million for a decade’s production. $75 million would represent an additional 7.5% of typical investment costs for a new plant. Corresponding figures for coal-fired DRI would be 3.5 times as high, with a decade’s worth of carbon tax representing $260 million.

Table 3.5 Illustrative calculation of cost of incentivising building of new plant to global best available technology

<table>
<thead>
<tr>
<th>Country</th>
<th>Option to be replaced by good BF</th>
<th>Business as usual new capacity (Mt/yr)</th>
<th>Emission Reductions (tCO₂/t steel)</th>
<th>Emission Reductions (MtCO₂/yr)</th>
<th>Required Investment Capital ($m/yr)</th>
<th>Required Investment Incentive ($m/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>BF (low eff)</td>
<td>2</td>
<td>0.2</td>
<td>0.4</td>
<td>1400</td>
<td>140</td>
</tr>
<tr>
<td>India</td>
<td>DRI (Coal)</td>
<td>1</td>
<td>0.7</td>
<td>0.7</td>
<td>700</td>
<td>200</td>
</tr>
</tbody>
</table>

Abatement Category 4: Increasing the use of recycled scrap

Using the Electric Arc Furnace route typically leads to emissions of 0.4 tCO₂/t steel, rather than the 2.0 tCO₂/t steel typical from a Blast Furnace. At a carbon price of $25/tCO₂, the value of carbon saved is thus $40/t steel, and financial payments could thus be justified at anywhere up to this level.

It is much more difficult to estimate how much extra scrap an extra payment of up to $40/t steel would lead to being collected. There is already a sizeable value for scrap steel (the main body of the report indicates that scrap steel is generally worth $250/t less than finished steel, i.e. around $350/t at a typical steel price of $600/t steel). While adding $40/t to the value of scrap would be significant, it is not obvious that it would make a major difference to the amount of scrap steel being collected.

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30 Assuming $700/t investment cost for all technology options
31 Assuming a 10% reduction in capital cost would be required to move from the lower efficiency Blast Furnace and a 25% reduction to move from coal-fired DRI (both in the form of a grant, lower interest rate, interest holiday, etc.)
3.2 Potential Role of the Carbon Market

A transnational approach, where a number of countries agree caps and trade allowances between them, can be discounted for at least the near future. The idea has received no political support from any developing country; it is not considered further in this study. This means that impacts on reducing competitiveness and leakage from the approaches and agreements considered in this study (the fourth criteria for assessment, in the first page of Section 3) will be weak at best. The study looks at approaches and agreements which are essentially national in nature, i.e. a steel sectoral approach for China does not necessarily have to have any common features or factors with one in India.32

At the individual plant or company level, a sectoral approach or agreement that only led to carbon prices at current and historic EU ETS levels (i.e. up to €30/tCO2) may not be effective in incentivising significant emission abatement. Referring to Tables 3.2 and 3.3: retiring obsolete plant is likely to require social policy and welfare payments; improving energy efficiency at existing plants appears to be constrained by the availability of investment capital; new build is often already at global best available technology and future carbon savings and payments may have little influence on the choice of new technology in any case; and there is already a strong financial incentive to collect scrap due to its financial value to steel producers.

But the carbon market would support the transfer of large financial flows to China and India. Alternatives, based on public financing, are unlikely to be able to generate such flows and there is considerable reluctance in many developed countries to make public finance available.

It is clear that a carbon price would incentivise abatement to some extent – and that the design of a Sectoral Approach or Agreement has a major influence on its effectiveness. The abatement categories require government action: it can regulate against obsolete existing plant (whilst providing compensatory payments to those affected by plant closures) and can set minimum standards governing the share of scrap which must be collected. Policies and measures could be fiscal or non-fiscal, and could include taxes, subsidy reform, trading schemes, mandatory regulation, policies specific to non price barriers and project-based mechanisms.

Thus if a sectoral approach or agreement resulted in payments being made to a government to incentivise the new policies and measures it implements, it may be more effective than if payments were made directly to individual plants or companies. At present, there is little in the way of proof of how effective such a scheme may be.

3.2.1 Key Choice: Setting Targets for Individual Abatement Categories or for the Sector as a Whole

There is considerable uncertainty as to the levels the baseline and targets would be set at, which would include political as well as technical considerations. In the initial stages, it is unlikely that developing countries would accept targets which would lead to penalty payments if they were not met – they would be likely to insist on Sector No-Lose Targets (SNLT). A degree of uncertainty will be inherent in the setting of baselines and targets, particularly in the early years of the scheme. There is thus a risk that the target could be set too strictly (weakening the incentive to abate) or the target could be set at too lax a level (leading to a windfall gain).

The key choice to be made is whether specific approaches should be provided for each of the four abatement categories, or whether a single approach could cover them all. The attraction of specific targets is that they allow better targeting and limit risk when uncertainty is high as to how much abatement each category could deliver, and at what cost. Specific targets could be set covering only some of the abatement categories or covering all of them. They could also be phased in over time. If specific targets were set for all abatement categories, a sectoral target would be created as the sum of the specific targets. A single sector target would have the advantage of flexibility, allowing reductions to be optimised between categories; its disadvantage is the risk that if one of the categories produced large amounts of reduction, which were subsequently considered to be non-additional, we would see under-
abatement from the other categories. It should be noted that the NAMAs\textsuperscript{33} currently being discussed under the UNFCCC could be used as the basis for either of the options.

Table 3.5 compares some of the key advantages and disadvantages of the two options; both options have their strengths and weaknesses. It is not straightforward to pick a clear ‘winner’. A single sector target is more flexible but is inherently riskier: targets are likely to be softer, data uncertainties will have a larger effect and there is a higher possibility of monetary transfers being made without any significant reduction in emissions. Better data availability, further analysis and better understanding of sectors and how they make decisions will reduce this uncertainty. It will clearly take time to implement any sectoral approach or agreement, and thus uncertainties can be reduced during the period of negotiations.

Table 3.5 Pros and Cons of Specific Targets and Single Sector Targets

<table>
<thead>
<tr>
<th>Issue</th>
<th>Comparison of the Options (Specific targets apply to the four abatement categories individually; single sector targets to the whole sector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>• Single sector targets better enables flexibility of which options can be used to make reductions. But this flexibility also makes it more open to gaming, i.e. if one option yields large numbers of credits without being additional, this will corrupt the whole system. Specific targets are both less flexible and less open to gaming.</td>
</tr>
<tr>
<td>Simplicity</td>
<td>• A single sector target is simpler and more transparent. It provides a simple indicator of progress, whereas specific targets would require a range of indicators which may be indirect (i.e. not measuring emission reductions directly). It enables international comparisons to be made.</td>
</tr>
<tr>
<td>Target-setting</td>
<td>• Both options have significant uncertainty, due to lack of data and ranges inherent in making projections.\textsuperscript{34} These uncertainties are magnified for a single sector target, since its target is made up by assessing targets for a number of constituent abatement opportunities. Experience (e.g. UK CCA, UK ETS) is that targets will be softer (easier to meet) as uncertainty increases. There is thus a higher possibility of soft targets being set under a single sector target.</td>
</tr>
<tr>
<td></td>
<td>• Targets will tend to be softer if they include the possibility of penalties if they are not met (as against ‘no lose’).</td>
</tr>
<tr>
<td></td>
<td>• Current difficulties with setting benchmarks for sectors which will receive free allowances under the EU ETS show how political and onerous target-setting becomes.</td>
</tr>
<tr>
<td></td>
<td>• It may prove difficult to negotiate specific targets if the outcomes of the negotiations are dependent on each other.</td>
</tr>
<tr>
<td>Development of New Policy</td>
<td>• Specific targets are directly linked to new policy development and implementation (noting that the indicators are indirect, rather than measuring emission reductions directly).</td>
</tr>
<tr>
<td></td>
<td>• A single sector target may lead to new policy development but the link is indirect.</td>
</tr>
<tr>
<td>Financial Transfer to Developing Countries</td>
<td>• Both options would allow transfers to be made. A single sector target is simpler to understand and more transparent.</td>
</tr>
</tbody>
</table>

3.2.2 Transferring Liability to Plants or Companies

The previous section concluded that it may be more effective if government took responsibility for a target or targets rather than assigning liability down to specific plants or companies. Such an approach would differ from the EU ETS, which sets liability at the installation level. One of the reasons for the EU ETS design is the belief that it is the individual installations that are best-placed to discover and act on abatement

\textsuperscript{33} Nationally Appropriate Mitigation Actions (for Developing Countries).

\textsuperscript{34} Noting that the Japanese sectoral approaches proposal of Professor Sawa of the 21\textsuperscript{st} Century Public Policy Institute proposes that targets could be modified as a function of sector output (i.e. if output were higher than expected, intensity targets would become automatically lower).
opportunities. Trading is also considered to be most efficient when markets are liquid, i.e. when there are many traders: installation-level liability is helpful here.

The sectoral approaches and agreements discussed internationally to date all effectively make the sector itself the liable entity. There have been no discussions of allowing plants or companies to be responsible: this is assumed to be a matter for national management. This does not preclude a national sector from apportioning its target to the constituent plants or companies. It is effectively an issue of wealth distribution, although certain choices could make enforcement more difficult.

Any apportionment methodology which was considered inequitable could be expected to raise more risk of non-enforceability. Thus we could allocate the same target to all producers (i.e. at the weighted average of production): those already under the average (e.g. EAF producers) would gain at the expense of those above (e.g. BOF producers). If an EAF producer has an emissions factor of 0.4 tCO₂/t steel and a BOF producer 2.0 tCO₂/t steel, then the average is 1.2. At $20/tCO₂, this would mean a transfer of $16/t BOF steel produced to the EAF producer, approximately 2.5% of price or maybe 25% of profits. This would need to be via an internal transfer of funds within the sector, either directly through an internal trading scheme or via the sector as an intermediary.

Average-based systems would be very likely to be seen as inequitable. Thus we could see a range of schemes proposed with varying levels of complexity. What needs to be taken care of is that the marginal incentive to abate is retained. Thus a scheme which differentiated between EAF and BOF routes may take away the incentive to move from a BOF to an EAF. The same may be seen in a scheme which distinguished between ‘new’ and ‘old’ plants: here we must retain the incentive to retire ‘old’ plant. Economic theory states that perfect allocation (a one-off allocation or auctioning) is the most efficient solution. A second best solution is allocation based on historical emissions and this looks to be a good starting point which would minimise inefficiencies. Closure and new entrant rules would need to be carefully though through to minimise economic distortions. The EU ETS provides good lessons on allocation which can be applied.

Carbon reductions should be independent of how a sector level target is distributed to producers provided no incentives are altered (i.e. that all producers see the same marginal cost of abatement). This will hold in the short term but will more complex in the long term (those benefitting from the initial allocation will have a stronger financial position in the future than those losing out, and the marginal use and need individual producers have for capital may vary significantly).

Non-enforcement of liability will either mean the sector being out of pocket (if this is possible legally) or for those producers who had beaten their targets losing some or all of their expected payments.

How sectors enforce liability appears to be a national sovereignty issue. One option could be a reserve payment (as traders have to make to be able to trade on certain exchanges). Regular updating of positions and provisional payments would be helpful but would require considerable administration. The essential question is whether sectors can make producers which miss their targets pay up or not. If not, the system will be likely to collapse quite quickly. A similar but more minor issue is what happens if producers become bankrupt or are taken over. The EU ETS again provides some useful experience of these issues.

### 3.3 Views of Stakeholders

#### 3.3.1 India

Sectoral approaches for the steel sector have not been addressed by the Government of India. More generally, however, sectoral agreements and approaches are viewed warily as a backdoor route to impose targets on India, illustrated by the following positions:

- “We welcome the sectoral approach as a method to reach targets, but targets are for developed countries,” said Nama Narain Meena, India’s environment minister.

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35 For example the current (end 2009) considerations under the EU ETS’ free allowance calculation may lead to a benchmark distinguished by a range of technological and product differences.

36 See Baron, Buchner and Ellis (2009) for a discussion of allocation of benefits and liabilities.

37 AFP (2008) [http://afp.google.com/article/ALeqMSihYxwzw___Nlf5cD27krG-X31sYHTA]
"While developed countries are free to adopt sectoral approaches as a means to achieve their national emission reduction targets, there cannot be an imposition of industry-wide norms on a global basis, nor recourse to arguments about maintaining trade competitiveness or a level playing field" said Shyam Saran, Special Envoy to Prime Minister for Climate Change.

The Government of India has until recently been reluctant to accept responsibility for mitigation of greenhouse gas emissions and there has therefore been a laissez-faire to policy regarding greenhouse gas mitigation technology. The Indian National Action Plan on Climate Change makes no comment on sectoral approaches specifically, but welcomes international cooperation for "research, development, sharing and transfer of technologies enabled by additional funding and a global IPR regime that facilitates technology transfer to developing countries under the UNFCCC".

The Indian steel sector has expressed no position on sectoral approaches and neither has the Confederation of Indian Industry (CII) although it does point out the success of the CDM and contemplates a domestic carbon market or an alternative carbon tax. Indirect evidence for Indian steel industry support for a sectoral agreement is suggested by the World Steel Association (WSA), who claim to have commitment from India for its Global Steel Sector Agreement.

India’s presentation to the AWG-LCA on sectoral approaches covers India’s issues with sectoral approaches (scale, diversity and intrusion of MRV).

Table 3.6 India's Views on Sectoral Approaches

<table>
<thead>
<tr>
<th>Stakeholder group</th>
<th>Views on sectoral approaches</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>Wary that sectoral approaches would establish binding targets for India. States that the argument for developing world inclusion in sectoral agreements on competitiveness grounds violates the basis of the UNFCCC.</td>
<td>Shyam Saran (2008): Speech to Confederation of Indian Industry. &quot;Climate Change – From Back Room to Board Room – What Indian Business Needs to Know About India's Approach to Multilateral Negotiations on Climate Change&quot;</td>
</tr>
<tr>
<td></td>
<td>Developed countries free to adopt sectoral approaches but there cannot be an imposition of industry-wide norms on a global basis, nor recourse to arguments about maintaining trade competitiveness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Committed to expanded CDM post 2012</td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>Indirect evidence for Indian steel industry commitment to WSA Global Steel Sectoral Agreement (GSSA)</td>
<td>WSA (2008), Global Steel Sectoral Approach</td>
</tr>
<tr>
<td>Commentators</td>
<td>Acceptance of mitigation responsibility is a fundamental issue</td>
<td>U. Sreenivasamurthy (2008)</td>
</tr>
</tbody>
</table>

3.3.2 China

No formal position has been laid out by the Government of China on sectoral approaches for the steel sector. More generally, China appears to have a similar understanding to that of India regarding the...
principal purpose of sectoral approaches; to aid the technological transfer. Xie Zhenhua, China’s chief climate change official was quoted as saying “China believes that using a sectoral approach is an important measure for implementing emissions reductions in every country. We can decide this for industries with high emissions levels and then transform the technology that these industries use to cut emissions”. 44

However, in difference to India, rhetoric has indicated a cautiously positive view of sectoral approaches. For example, China has repeatedly stated that sectoral approaches represent important mechanisms for combating climate change. The summary of the joint statement released following Chinese President Hu Jintao’s first state visit to Japan illustrates this: ”The Chinese side expressed a view that sectoral approaches in fighting climate change is an important method, and both sides will further study what role such approaches can serve”45.

A comprehensive description of Chinese positions on sectoral approaches was presented at a workshop of the UNFCCC working group on Long-term Cooperative Action held in Accra during August 200846. The Chinese representatives concluded that:

- the discussion on cooperative sectoral approaches should strictly concentrate on Article 4.1(c) of the UNFCCC
- “cooperative sector approaches and sector-specific actions should be considered within development context and match stage and level of socio-economic development”
- "Capacity building, development and transfer of technologies, and financing should be major components of cooperative sectoral approaches"

Industry positions in China are difficult to judge, but the WSA does state that it has Chinese commitment for its GSSA proposal.

Table 3.7 China’s Views on Sectoral Approaches

<table>
<thead>
<tr>
<th>Stakeholder group</th>
<th>Views on sectoral approaches</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Government</strong></td>
<td>Sectoral approaches are an important mechanism in fighting climate change but further study is needed into what role such approaches can serve</td>
<td>Reuters (7th May 2008), China says industry approach useful in climate fight.46</td>
</tr>
<tr>
<td></td>
<td>For carbon intensive industries, sectoral approaches are important for all countries to transfer mitigation technologies, i.e. approaches should focus on UNFCCC Art. 4, para. 1(c). global sectoral standards, benchmarks or emission reduction targets is not acceptable</td>
<td>Xie Zhenhua quoted on 28th Oct 2008.44</td>
</tr>
<tr>
<td></td>
<td>Cooperative sectoral approaches should serve both mitigation and adaptation</td>
<td>W. Can and J. Zou (2008), China's Views on how to enhance implementation of Article 4.1(c) of the Convention through Cooperative Sectoral Approaches and Sector-specific Actions, Accra, 21st August 200846</td>
</tr>
<tr>
<td><strong>Industry</strong></td>
<td>Indirect evidence for commitment to WSA GSSA</td>
<td>WSA (2008), Global Steel Sectoral Approach</td>
</tr>
<tr>
<td><strong>Commentators</strong></td>
<td>Particular interest in a technology-oriented approach in a post-2012 climate regime. Technological innovation is a high political national priority.</td>
<td>IEA (2009), Sectoral approaches and the carbon market. (R. Baron, B. Buchner, J. Ellis)</td>
</tr>
</tbody>
</table>

45 http://www.reuters.com/article/latestCrisis/idUSPEK346788
46 http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/2_china_sa.pdf
3.4 Implementing Sectoral Approaches and Agreements

Whatever type of scheme is implemented, it will take time to operationalise. The more complex the scheme, both in terms of MRV requirements and political considerations, the longer we can expect that it will take to operationalise. It seems unlikely that any scheme could be operationalised in less than 3 years.

A number of steps can be envisaged on the path to global trading. Various studies have mapped out these steps and associated timescales. A study by IISD47, published earlier in 2009, is representative of the literature. Its "Phased Approach to a Safe Climate" is shown in Figure 3.1. It distinguishes between 'developed', 'advanced developing' (which would include China) and 'other developing' countries (which would include India). Steps are set for each group of countries, with taking the next step dependent on all countries having met their commitments under the previous step (thus engendering trust). They would be taken every 5-10 years.

A phased approach appears sensible. The next question is of course what the steps would entail. The following three steps could apply:

a) Capacity-building and Limited Crediting: collection of data to agreed protocols (almost certainly the WSA’s protocol), understanding of what options a country has to abate its emissions, development of sector policies in support of Sectoral Approaches and Agreements, developed countries providing technical and financial assistance as required. Generation of some credits against either a single sector target or set of specific targets. “No lose” approach, i.e. no penalty payments for failure to meet targets;

b) Full Sectoral Trading against Single Sector Target;

c) Full Sectoral Trading against Absolute Caps.

We could expect China to progress more quickly than India. Both China and India could move immediately to step (b), or spend a relatively short period under step (a). There is considerable uncertainty relating to many issues, from cost data and abatement potential to the political and practical issues of setting baselines and targets. Whatever pathway is followed, it must allow sufficient capacity-building and understanding to develop.

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Figure 3.1  IISD Phased Approach to a Safe Climate

**Phased Approach to a Safe Climate**

**Goal:** To encourage deep cuts in global GHG emissions by 2050

**Phase I**
- to 2017 for developed countries
- to 2030 for developing countries

**Developed Countries**
(includes all OECD members and EU Member States)
- Individual country low-carbon plans to reach long-term goal.
- GHG inventories submitted on an annual basis.
- Access to market-based mechanisms.
- Commitment to joint developed and developing country R&D program(s) for critical technologies.
- Establishment of climate change fund(s) for mitigation and adaptation in developing countries with multiple sources of revenue including grant funding, auctioning of AAUs and international market-based levies.

**Phase II**
- Post-2017 for developed countries
- Post-2030 for developing countries
- Targets and actions based on a review of the scientific adequacy of emission reductions in developed countries in 2014.
- Regime continues, with updates in individual country plans and potential revisions in milestones/targets based on at least a decadal basis, informed by new science and technology information.

**Advanced Developing Countries**
Any country reaching agreed criteria of an advanced developing country will take on commitments as set out below. Criteria to include: per capita GDP, contribution to overall GHG emissions and ability/capability to contribute to obtaining GHG emission reductions.
(The group could include Bahamas, Brazil, Chile, China, Kuwait, Saudi Arabia, Singapore, South Africa, Qatar and United Arab Emirates)

- Begin setting sectoral/sub-national no-lose targets with a base year of 2005 in preparation for national targets starting in 2017.
- Individual country NAMA plans, registered with the UNFCCC.
- GHG inventories submitted on a biennial basis and include reporting on sectoral/sub-national no-lose targets, and GHG emission reductions linked to actions under NAMA plans.
- Access to financing through market-based mechanisms.
- Commitment to joint developed and developing country R&D program(s) for critical technologies.
- Access to financing from new funds for NAMAs, REDD, technology and capacity building activities.

**Other Developing Countries**
All other developing countries, with recognition of the unique and not always common needs and responsibilities.
Provided that developed countries meet their collective 2017 goal for the post-2020 period:
- Binding commitments based on a long-term goal to 2050 and collective/national goals at 2020, 2030 and 2040 from a 2005 baseline.
- Individual country low-carbon plans to reach long-term goal.
- GHG inventories submitted on an annual basis.
- Access to market-based mechanisms.
- Commitment to joint developed and developing country R&D program(s) for critical technologies.
- Financial contributions to NAMAs and adaptation in LDCs.

No commitments, but encouraged to develop NAMAs and register them to access financial and capacity building support for actions. (LDCs able to access financing prior to the developing of NAMA plans; other developing countries require plans to access funds.)
- Access to financing from new funds for NAMAs, REDD, technology and adaptation.
- Access to financing through market mechanisms.
- GHG inventories submitted on a biennial basis and include reporting on GHG emission reductions linked to actions under NAMA plans.
- Differentiation within this group is explicitly recognized.
4 Conclusions and Recommendations

4.1 Key Insights on the steel sector in India and China

- **Steel is an important sector in terms of carbon emissions and its abatement**: it accounts for 5% of global emissions from fossil fuel combustion; its emissions are projected to grow by at least 50% in the period 2005-30, even if emission abatement options are implemented; and the sector is vulnerable to emissions leakage (40% of steel is currently traded internationally).

- **China is the world market leader in steel, with India on a high growth path. China produces around 500 million tonnes /yr** (40% of world market share) and India 55 million tonnes /yr. They are both projected to grow substantially.

- **There are abatement activities already underway as part of business as usual in China and India, but there is still scope for incentivising more through Sectoral Approaches and Agreements**. These should incentivise governments to focus on removing non-price barriers (such as access to investment finance) in addition to strengthening the carbon price signal.

- **Much of the new build in China and India is already taking place at best available technology (BAT)**. Abatement potential from improving new build is thus limited. Other abatement options involve improving efficiency at existing plants, replacing older, less efficient plant and increasing scrap recycling. These are considered to have low or zero marginal abatement costs, but encounter barriers including high capital costs.

- **In general, there do not seem to be many deep abatement opportunities in steel in the short-medium term**. This sector, with its ‘locked-in’ technology, perhaps has more in common with aviation than with say power generation that has more technology options that could radically reduce emissions. Excluding demand reduction, CCS (carbon capture and storage) and other breakthrough technologies are necessary for deep cuts but are unlikely to be relevant before at least 2020.

- **There is considerable uncertainty in estimating what the scale of abatement could be, what the business-as-usual baseline is, what the target should be against which credit would be given and how sectoral approaches and agreements may impact take-up**. Initial modelling suggests that, within a decade, China could abate up to 150 MtCO2/year and India up to 40 MtCO2. If a target were set in the middle of a range defined by a baseline based on stock turnover only and a projection with the maximum identified abatement, and if the carbon price were $25/tCO2, China could harness up to $2bn per annum from the sale of credits, and India up to $0.5bn. Where the baseline and targets would be set would be a result of negotiation.

4.2 Conclusions

China and India are already making reductions in their emissions below what would be expected from stock turnover alone. Sectoral Approaches and Agreements could incentivise further reductions. How effective they would be is not yet clear and building up experience on what the steel sector’s abatement potential is, and how abatement can best be incentivised, is necessary.

An effective Sectoral Approach or Agreement would need to overcome both price and non-price barriers. Apportioning a sector target to individual plants and relying on the resultant carbon price alone to drive abatement is unlikely to yield significant reductions in the steel sector. Politically, transnational trading does not appear to be a viable option in at least the medium-term. A national approach, ideally with price and non-price incentives, is thus indicated.

A key part of scheme design is whether it should target a number of individual abatement categories or the sector as a whole. An approach specific to the abatement categories (four currently available categories have been identified in this study) would lower the risks resulting from the considerable uncertainties in abatement costs and potentials and what business-as-usual emissions from the sector would be. But it would be less flexible than a single target for the sector – it would not allow abatement to be optimised across all the sector’s options. This study concludes that there is potential for Sectoral Approaches and Agreements, carefully designed to account for the realities of the steel sector, its abatement options and the
state of available information, to incentivise abatement in China and India beyond what they are currently achieving.

4.3 Further Work

The steel sector is a key one and it must make progress in controlling its emissions going forward. Sectoral Approaches and Agreements are certainly worthy of further analysis. Further work should focus on better:

- data collection;
- analysis of the available data;
- understanding of the impacts on stakeholders of schemes and their design, based on an analysis of company and organisational structure.

The wider Climate Strategies project on Sectoral Approaches and Agreements aims to meet these needs during 2010. It will develop model agreements, using progressive discussions with stakeholders, in a set of case study countries (India, Japan and China). From these, it will develop a synthesis document.
Annex A: Drivers of Decision-Making in the Steel Sector

A1 Plant Sizes, Costs and Lifetimes

Integrated steel mills (BF/BOF combination) must have a capacity of over 1 million tonnes crude steel per year (1 Mtpa) to be economic. The investment cost is typically $700/t crude steel capacity, giving an investment cost of $1 billion for a typical 'mid-size' module of 1.5 Mtpa, and $2 billion for a capacity of 3 Mtpa (the normal size for the economic production of flat products). New plant being considered in the Gulf and parts of Asia are being proposed with sizes of 6 Mtpa and above in order to access the continuing economies of scale, but plant greater than 3 Mtpa has rarely been built in practice.

Figure A1 shows how a capital cost of $700/t crude steel capacity is levelised per tonne of steel production, using a range of discount rates and economic lifetimes. Paying back capital over 20 years with a 10% real discount rate requires a contribution of $80/t steel. At 15% discount rate this increases to $120 t/steel; at 5% discount rate, it decreases to $50/t steel. This compares to a typical steel price of $600/t (see Section A1.2 for further discussion on price).

DRI/EAF and EAF-only plant can be significantly smaller, and therefore require a much lower investment (in absolute terms). Sizes in the range 0.15-0.5 Mtpa are typical. Providing there is demand for the products they make, they can allow small, niche players to enter the market.

The ages and lifetimes of plants are difficult to pin down precisely, as a plant may include some modern parts and some that are much older. A typical plant lifetime is around 40 years; it is also usual to use brownfield sites wherever possible when building new plant or increasing capacity.

A1.1 Types of Steel Produced

There are essentially two types of steel: 'long' and 'flat'

'Long' products include wire rod and reinforcing bar ("rebar") and represent the low end of the market – general construction materials, not requiring a high specification. DRI/EAF and EAF-only routes can produce such materials, since the alloys and other impurities present in scrap steel are not an issue for this grade of product. 'Long' steel can be produced by EAF plant for local markets but is also readily traded on the world market.

'Flat' products are higher quality and are often produced for particular orders and customers. They tend to need to start with pure iron and are thus predominantly from the BF/BOF route. Key products are slabs and Hot Rolled Coil (HRC). 'Flat' products are also extensively traded on the world market.

Long (rebar) and flat (HRC) products are shown in Figure A2.

**Figure A2. Long (rebar) and Flat (HRC) products**

A1.2 Price of Steel

Steel typically retails for $600/t. Its price varies markedly over the economic cycle – approximately half of steel is used in the construction sector (see Figure A3).

The world price for HRC was $639/t⁴⁹ in January 2008 and peaked at $1100/t in July 2008. By April 2009, it had fallen by over 55% from this peak to under $500/t.

There is some variation in price by region (prices in Asia tend to be somewhat lower than in the EU and US), but it is relatively minor. Long products (the widely-traded products from DRI-EAF and EAF routes) are typically up to $100/t less expensive than flat products.

Speciality steels, such as stainless steel, command much higher prices. A typical price for stainless steel is of the order of $3000/t, i.e. five times that of the basic product. The production of speciality steels allows higher production cost countries such as Japan to gain some market benefit through their advantages in technical and managerial expertise (requirements for speciality steels are much higher than for the more basic steels, where process management can basically be automated). Nevertheless, the majority of steel produced and traded is essentially on a commodity, rather than specialised, basis.

⁴⁹ See [http://www.steelonthenet.com/prices.html](http://www.steelonthenet.com/prices.html) for price series by steel product
No single item dominates production costs from BOF. Figure A5 shows that five items – raw materials & alloys, fuel & electricity, services & overhead, labour and capital – each account for roughly equal shares of the total production cost. Note that this figure is for 2004, when overall production costs were lower than they are today. It has been used only to illustrate the make-up of costs, not their overall level.

Steel is one of the few industries where carbon costs could significantly increase production costs. Figure A5 additionally shows that a carbon price of €20/tonne CO₂ applied to a BOF/BF route with emissions of 2 tCO₂/t steel would add €40/tonne to the production cost of steel (or around 15% at the production cost level).
shown in the Figure). This is a significant sum in an industry where margins are tight for many producers and where the intensity of trade is high (at around 40% of world consumption).

Figure A6 shows preliminary EU analysis of the potential impact of a carbon cost of €30/t CO₂ on prices for two steel products. Rebar (long product) shows a 30% price increase from direct and indirect costs, and a 50% trade intensity\(^5\); HRC cost increase is 15% with a 30% trade intensity.

**Figure A5** Make-up of Slab Production Cost, 2004

**Figure A6** Impact of a €30/t CO₂ Cost on Selected Industrial Products

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\(^5\) Defined as the sum of imports and exports divided by domestic consumption.
Finally it is interesting to note the potential impact of carbon costs on value added (or “value at stake”). Figure A7 gives a representative analysis for the UK, adapted from Hourcade et al’s 2007 study. The Figure shows that iron & steel would see the second largest impact on value added (after lime and cement production). At a carbon price of €20/t CO₂, total direct and indirect costs would represent approximately 25% of value added.

Figure A7. Carbon Cost Impact as a share of Value Added

**Figure 3.2: Possible impacts of EU-ETS on UK manufacturing sector (20EUR/tCO₂).** Direct and indirect cost impacts on manufacturing sub-sectors in the UK - assuming 20EUR/tCO₂ carbon price and corresponding 10EUR/MWh electricity price increase: 2004 data. Source: Sato and Mohr, 2008 adapted from Hourcade et al 2007

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### A1.4 The Influence of Industrial Policy

The last 15 years have seen major changes in the steel sector in many countries. Consolidation, privatisation and mergers and acquisitions have moved the industry away from aligned national production and ownership in many countries. This trend has reduced the strong links that existed between government and the industry, making government less willing to grant subsidies to companies who may be partially or wholly "foreign" and making industry less willing to accept the conditions that accepting subsidies would require. The EU has progressively eliminated subsidies from 1985/6 onwards.

Nevertheless it is widely understood that certain subsidies to the steel sector remain, at least in some countries. The OECD Steel Committee has identified these as occurring at all points in the chain: support to initial investments, trade-related support and support to ailing industries. Each of these contributes to over-capacity which makes producers more vulnerable to cyclical downturns (see Figure A8).

The OECD Steel Committee has made periodic attempts to get its membership to agree to subsidy reform, based on the premise that unilateral subsidy reform would not be a successful policy. There has been little progress to date for a variety of reasons, including US reluctance to agree to limit the trade remedies available to it and inability for US Federal negotiators to discipline individual States.

Financial subsidies are almost certainly decreasing in importance. The most important that remain are probably the low fuel prices that producers in countries in parts of the Gulf, East Asia and the Former Soviet Union continue to receive. Looking forward, the financial costs of climate change policy, notably including whether allowances are granted for free under Emission Trading Schemes (ETSSs), are likely to be at least as large as any remaining financial subsidies.
World steelmaking capacity, crude steel production and finished steel consumption

With steelmaking capacity having outstripped the growth of steel consumption in recent years, and as steel demand is now contracting due to the global economic downturn, it appears that the global steel industry is facing a situation of overcapacity.
A2  World Production and Trade

A2.1  World Production

World production of steel is currently of the order of 1100 Mt/year, down from a peak of 1400 Mt/year in 2008 (see Figure A9). The growth in the past decade has been driven by developing economies, notably China. It is these economies whose demand has also held up best during the current downturn.

Figure A9  Global Crude Steel Production, 1950-2008

![Global crude steel production](image)

Figure A10 shows national steel production over the 90-year period to 2005. The US was the world’s largest producer until the 1970s, but its production has now stabilised at around 100 Mtpa. Japan and the CIS (former Soviet Union) have similar outputs. The meteoric rise of Chinese capacity is illustrated – China alone added 78 Mt of new capacity in 2005, and now accounts for around 40% of world output. This growth has required huge shipments of iron ore to China, notably from Brazil and Australia. These shipments contributed to the major increases in shipping costs seen in the period 2002-08.

Chinese output is expected to saturate in the near future. Figure A11 shows two sources which both see China’s production stabilising at 600 Mtpa in the near future. India is expected to be the next country with major growth, with 100 Mt new capacity per decade (10 Mt new capacity per year) projected in the period to 2050. This would increase Indian capacity from its current 55 to 500 Mtpa.
Tsinghua University (2009) and RITE (2008):

- both in broad alignment with IEA high demand case for China over next decade (approx. 625Mt in 2015); suggests production to peak in 2020-2040 and decline thereafter
- RITE (2008) suggests stronger growth in India to 2050 compared to IEA (500Mt vs. 450Mt IEA high case)

### A2.2 International Trade

Figure A12 indicates that trade has grown strongly over the past 30 years. Trade between regions in 2008 was of the order of 300 Mtpa, i.e. 20-25% of world production. Total international trade, including that between countries within regions, represented over 500 Mtpa in 2008 (approximately 40% of world production).

The key exporters of steel are USSR/CIS, EC and Asia. The largest importers are Africa/Middle East, EC and North America. The EC is a good example of how regions and countries both import and export steel. Often countries will export a surplus of one type of steel and import a deficit of another, rather than seeking to be self-sufficient in all products. This trend is expected to strengthen going forward, with the share of production traded increasing.
A2.3 Impact of Transport Costs

Steel is a relatively heavy product and transport costs are significant. The same logic applies to the key inputs to steel manufacture: iron ore, coal and limestone.

The costs of bulk dry transport increased dramatically over the period 2002-08. Figure A13 shows that the cost increased from $32/t steel to over $90/t steel in the period 2006-08. In 2008, analysts were expecting that the combined transport cost of importing iron ore into China and then exporting the finished steel would make Chinese steel uneconomic at spot rates and would curtail Chinese exports, at least to markets far away (e.g. Europe).

A rise of $60/t steel is equivalent to a carbon price of $30/t CO$_2$ for steel from a BF/BOF route with emissions of 2tCO$_2$/t steel. The economic crisis has since reduced steel transport costs back below 2006 levels.

Transport costs, and the relationships that local suppliers build up with local customers, explain why there tends to be a differential between the price that local suppliers can charge and that with importers can charge. In modelling, this is generally modelled as an “Armington elasticity”, with importers needing to undercut local suppliers in order to gain market share.
Figure A13  Steel and Iron Ore Transport, Asia to Europe
A3 Ownership and Organisation of Companies in China and India

A3.1 China

China has a wide range of ownership types and sizes. Figure A14 covers 67% of China’s 2008 production: 43% state-owned and 24% private. The unidentifed remainder includes a large number of small plants, many owned by local municipalities.

Foreign ownership of facilities is not possible (they are limited to a minority stake). Thus, for example Japanese companies are not fully incentivised to invest; they are willing to sell their technology at market rates and to take consultancy contracts for its subsequent management. Chinese companies have not been active in overseas investment to date.

The National Development and Reform Commission’s (NDRC’s) 11th five year plan puts focus on closure of the smallest sites and the same commission asked in 2005 for its top ten steel producers to account for 50 percent of domestic output by 2010 and 70 percent by 2020. As a result there has been a considerable amount of consolidation in the Chinese steel industry, with large players acquiring smaller entities and investing in development. Recent evidence suggests this pattern of expansion is set to continue:

- Baosteel, China’s largest steel producer is set to acquire Ningbo Iron & Steel Group and Baotou Iron & Steel Group, according to Chi Jingdong, the China Iron and Steel Association’s (CISA’s) secretary-general.
- Rizhao Iron and Steel, one of China’s largest private-sector steel mills, has signed an agreement to consolidate with Shandong Iron and Steel.

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In 2008, Baosteel launched a joint venture with Shaoguan Iron and Steel Group and Guangzhou Iron and Steel Group to launch a new company Guangdong Iron and Steel Group Corp. By way of expansion, Baosteel aims to build a new steel mill with an annual capacity of 10 million tonnes to be headquartered in the port city of Zhanjiang city, also in the Guangdong province.

CISA states that China’s biggest steel producers are expanding capacity at plants along the coast in addition to the Zhanjiang plant described above. Development is taking place in Fangcheng Port and Rizhao. Steel plants in coastal areas should make up 20 percent of the nation’s total capacity by 2011, Chi Jingdong of CISA said.

Company literature for Chinese steel companies has been difficult to obtain and where published in English has yielded little useful information on expansion activities. Table A1 lists some of the development projects detailed on the Baosteel website and in the Baosteel 2007 Annual Report. Importantly, all three projects are either developments following merger or joint ventures. The Luoqing Engineering project introduces the new COREX-C3000 smelting reduction process to Baosteel’s Pudong Iron and Steel Company. The expansion of the furnace at Bayi new area follows the merger with Bayi Steel Co., whilst the 5 Mt/yr blast furnace is part of a joint venture with Hanbao Iron and Steel Co.

However, reports suggest that the Chinese Government may curb near-term expansion of steel production capacity. The Chinese Government is working on plans to curb excess capacity, which will increase consolidation in the industry as well as lead to the closure of outdated facilities. The NDRC is also unlikely to approve this year a feasibility report on Wuhan Steel’s planned 10 million-ton steel plant at Fangcheng Port in the southwestern province of Guangxi. It is reported that Premier Jiabao has asked WISCO to build the plant at an appropriate time.

### Table A1 Selected Baosteel Capacity Expansion

<table>
<thead>
<tr>
<th>Project</th>
<th>Type</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luoqing Engineering Project - Ph 2</td>
<td>COREX-C3000</td>
<td>3.14 Mt/yr</td>
</tr>
<tr>
<td>Bayi Steel new area, Xinjiang Uygur Autonomous Region</td>
<td>Blast Furnace</td>
<td>2,500 m³</td>
</tr>
<tr>
<td>Hanbao Iron &amp; Steel Co., Ltd</td>
<td>Blast furnace</td>
<td>5 Mt/yr</td>
</tr>
</tbody>
</table>

#### A3.2 India

Nearly three-quarters of India’s domestic steel production is manufactured by four organisations: Tata steel, Steel Authority of India (SAIL), Essar Steel and Jindal Steel and Power Ltd. (see Table A2). Of these, only SAIL is state-owned. ArcelorMittal has facilities in 20 countries but currently no primary production in India.

The “unidentified” group refers to the difference between quoted total Indian domestic steel production and that attributed to major companies or organisations. Direct Reduced Iron (DRI) production is widespread in India, as are mini blast furnaces, EAFs, induction furnaces and energy optimising furnaces. This production can be attributed to large numbers of small-scale producers. This is significant for a sectoral agreement or approach: these small plants are essentially outside the system and an attempt by Indian authorities to assert control over them would be turning the clock back significantly (and controversially).

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53 Reuters, Baosteel to pay $4.2 billion for Guangdong acquisition, 23rd Jun 2008 (http://www.reuters.com/article/innovationNews/idUSSHA21729220080623)
Table A2  Indian Production, 2008

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Production 2008 (Mt/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tata (domestic)</td>
<td>11.0</td>
</tr>
<tr>
<td>SAIL</td>
<td>13.4</td>
</tr>
<tr>
<td>Essar</td>
<td>9.7</td>
</tr>
<tr>
<td>Jindal Steel and Power Ltd⁵⁷</td>
<td>6.7</td>
</tr>
<tr>
<td>Vizag steel</td>
<td>3.4</td>
</tr>
<tr>
<td>Bushan</td>
<td>1.0</td>
</tr>
<tr>
<td>Lloyds steel group</td>
<td>1.0</td>
</tr>
<tr>
<td>Unidentified</td>
<td>8.9</td>
</tr>
</tbody>
</table>

**India domestic steel production** 55.2

Table A3 sets out the domestic and overseas operations of the top five steel producers in India. Tata Steel’s overseas capacity is over twice its Indian capacity, and Essar owns a 2.4 Mtpa plant in Canada.

Table A3  Domestic and Overseas Operations of top 5 Indian Domestic Producers, 2008

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Domestic</th>
<th>International</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Site</td>
<td>Capacity (Mt/yr)</td>
</tr>
<tr>
<td>Tata Steel</td>
<td>Jamshedpur, Jharkhand, India</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td>Tata Metaliks, Maharashtra &amp; West Bengal</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>Tata Sponge Iron Ltd, Orissa</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total</strong></td>
</tr>
<tr>
<td>SAIL</td>
<td>Bhilai, India</td>
<td>3.16</td>
</tr>
<tr>
<td></td>
<td>Bokaro, India</td>
<td>4.50</td>
</tr>
<tr>
<td></td>
<td>Durgapur, India</td>
<td>1.80</td>
</tr>
<tr>
<td></td>
<td>Rourkaela, Orissa, India</td>
<td>1.90</td>
</tr>
<tr>
<td></td>
<td>ISCO, Burnpur, India</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>12.03</strong></td>
</tr>
<tr>
<td>Essar</td>
<td>Hazira, Gujarat, India</td>
<td>5.10</td>
</tr>
<tr>
<td></td>
<td>Hazira, Gujarat, India</td>
<td>4.60</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>9.70</strong></td>
</tr>
<tr>
<td>Jindal Steel and Power</td>
<td>Raigarh, Chattisgarh, India</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>Raigarh, Chattisgarh, India</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>Raigarh, Chattisgarh, India</td>
<td>2.40</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>6.70</strong></td>
</tr>
<tr>
<td>Vizag steel</td>
<td>Visakhapatnam, India</td>
<td>3.40</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>3.40</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Domestic</strong></td>
<td><strong>42.87</strong></td>
</tr>
</tbody>
</table>

⁵⁷ Note that JSW has been split into 4 companies.
A3.3 Industry Associations

Four key organisations represent the iron & steel sector:

1. The World Steel Association (WSA; [www.worldsteel.org](http://www.worldsteel.org)): Founded in 1967, and previously the International Iron and Steel Institute (IISI), the WSA now has 180 members (including 19 of the top 20 world producers), national and regional steel industry associations, and steel research institutes;

2. Regional steel associations (such as Europe’s Eurofer and AISA in the US) exert strong influence on trade policy and positions;

3. The OECD Steel Committee ([http://www.oecd.org/about/0,3347,en_2649_34221_1_1_1_1_1,00.html](http://www.oecd.org/about/0,3347,en_2649_34221_1_1_1_1_1,00.html)). With its 33 members including Brazil, Romania, Russian Federation, Slovenia and Ukraine (awaiting ratification), as well as its Observers (Argentina, Bulgaria, Egypt, India, Malaysia, South Africa and Chinese Taipei), the OECD Steel committee, Members and observers account for around 60% of world steel production and 76% of world exports of steel. China is also present at its meetings. “While the OECD is not the place to establish and supervise legally binding rules of the steel market, it has emerged over the years as the unique platform where multilateral steel problems can be discussed and political solutions found. Analytical capacity, policy dialogue and political commitments are the driving forces that govern this Committee.”

4. The APP (Asia-Pacific Partnership on Clean Development and Climate; [http://www.asiapacificpartnership.org/english/default.aspx](http://www.asiapacificpartnership.org/english/default.aspx)) has 7 members, representing many of the world’s largest steel producers (Australia, Canada, China, India, Japan, Korea, and the United States). It has a dedicated Steel Task Force, chaired by Japan. This Task Force has worked to improve information and co-operation between its members, sharing best practice on energy efficiency and improving conditions for commercial transactions.

A4 Evidence from the CDM

283 iron & steel projects have been submitted under the CDM (October 2009 pipeline). Of these, a total of 227 are expected to be validated, including 138 are at the validation stage and 78 registered.

China and India have dominated the projects, each being responsible for over 100 (see Figure A15). The Chinese projects have on average been significantly larger: China has a 70% share of the estimated 42.4 MtCO$_2$/year the 227 projects are expected to generate, compared to India’s share of 26%.

Figure A15 CDM Projects Expected to be Validated

Total expected reductions of 42.4 MtCO$_2$/year represent approximately 3% of the global potential identified by McKinsey for 2030. The CDM cannot be expected to be a major part of overall reductions but it does give us a good idea of the sort of options which are being implemented with support from the carbon market. Analysis of the 227 projects shows that Waste Heat Recovery (WHR) is the dominant technology, accounting for 77% of projects alone and sharing in other projects too (see Figure A17). The 77% of WHR projects account for 88% of expected reductions.
The consideration of what constitutes best available technology for new build focuses on a number of key technologies and processes. Four of the most important, and how many times they appear as the key title of a CDM project, are:

1. Coke Dry Quenching (CDQ): 23 times – 20 China, 2 India;
2. Top Gas Recovery Turbine (TRT): 14 times – 12 China, 2 India;
3. Coke Oven Gas (COG) use for Power Generation: 14 times, all China;
4. Blast Furnace Gas (BFG) use for Power Generation: 18 times - 13 China, 3 India.

It is clear that China has dominated the use of CDM for these options. They can lead to major emissions reductions: Figure A17 shows that average reductions are between 100,000 and 400,000 tCO2/year per plant. If we assume that an average plant is producing of the order of 2 Mtpa of steel and emitting 4 MtCO2/year, the technologies can therefore save 2.5-10% of emissions on average.

COG and BFG are standard technologies at plants in developed countries. CDQ is standard in Japan but not in certain other developed countries. It is understood that all new Chinese Blast Furnace plant must now recover COG and BFG for power generation and include CDQ technology. The CDM is thus useful to assess what can be done at existing plant but is not necessarily a good guide for new build.
A5  Chinese Production, Policy and Plans

China’s production in 2008 was 500.5 Mt steel, of which 91% was BF/BOF and 9% EAF. There is no DRI.

For China’s generic climate change policy, see Annex B.

A5.1  Government Policy and Plans

From China’s Climate Change Program (June 2007):

- Iron and steel industry: **coke ovens should be equipped with coke dry quenching (CDQ)** facilities, and **new constructed blast furnace should be equipped with furnace top pressure differential power generating equipment (TRT)**; apply advanced technologies and equipments such as beneficiated material feeding, **rich oxygen coal spurt (PCI)**, molten iron pre-treatment, large-scale blast furnace, converter, and super power electric arc furnace, external furnace refining, continuous casting, continuous rolling, controlled casting and controlled cooling.
- To encourage the saving of iron and steel, and restrict the export of steel products. For this purpose, China will further carry out the Development Policy for Iron and Steel Industry, **encourage substitution of renewable materials for iron and steel and recycle of waste steel to reduce steel use**; encourage the application of the short-flow process technique using waste steel as material for steel production; organize the revision and improvement of the Standard for Constructional Steel Design and Utilization to reduce steel service factor on the precondition that safety is ensured; encourage the research, development, and deployment of high-performance, low-cost and low-consumption new materials as substitute for steel; encourage iron and steel plants to produce high-strength steel and corrosion-resistant steel to enhance steel’s strength and service life; restrict the export of ferroalloy, pig iron, waste steel, steel billet and ingot, rolled steel and other steel products; abolish the export tax rebate policy or at least lower the rebate rate for export of steel products.

The central government planned to limit the country’s overall steelmaking capacity to 400 million tpa (tonnes per year) during the 11th Five-Year Plan (2006-2010) and intended to eliminate existing backward
upstream facilities, i.e. about 100 million tonnes of iron-making capacity and 55 million tonnes of steelmaking capacity (small EAF) in line with the New Steel Policy. The government will also encourage steelmakers through consolidation and cross shareholdings to reduce their numbers and create stronger entities.

The New Steel Policy was issued by the NDRC in July 2005, laying out a blueprint for the sector over the next 15 years. It aims to lead the sector to sustainable and healthy development by overcoming several structural problems which have occurred or have aggravated the process of its rapid development in the past few years, e.g. (i) over-capacity caused by irrational investments; (ii) lack of industrial concentration; (iii) imbalanced product mix (excess of lower grade products, shortage of high value-added products); (iv) poor industrial layout (difficulty in transportation, pollution in the cities); and (v) waste of natural resources and energy, pollutant emissions.

Relating to (v) the following goals are made:

- For the environmental protection and effective utilisation of natural resources, consumption of energy and water (per crude steel tonne) should fall from 0.76 tonnes of coal equivalent and 12 tonnes of water in 2005 to 0.73 and 8 tonnes respectively in 2010, and 0.7 and 6 tonnes in 2020. Steelmakers should develop power generation systems to reuse waste heat and energy at their plants. (Chinese government Energy efficiency targets (Mid & Long-term Energy Conservation Plan 2004, in support of the 11th 5-year plan)

Therefore, Government plan is to achieve 700kge/t steel in 2020. This is equivalent to 1.82 tCO₂/t steel (assuming CO₂ intensity of coal = 3.762GgCO₂/10¹⁰ kcal and calorific value of coal = 6,928 kcal/kg).

A5.2 Current and Future Technology

The Global Times (13 August 2009) reported that China's Ministry of Industry and Information Technology (MIIT), “announces a three-year moratorium on approvals of new expansion-related proposals in the iron and steel industry, as the government pledges to eliminate outdated capacity.” MIIT estimated total output capacity at 660 million tonnes, compared with estimated demand at 470 million tonnes. MIIT called for steel mills to stop expansions for the next three years. MIIT is drafting steel industry consolidation guidelines aimed at reforming the Chinese steel market. MIIT will issue guidance on energy saving and emission reduction for key industries in the second half of 2009. In addition, they will compare main standards of energy consumption of the steel and chemical industries with that of international advanced level to find the gap so that proper efforts will be made to catch up.

Tsinghua University, 2008 reported that Chinese industrial policy requires new BF to have TRT (top-pressure recovery turbines). Only 66 BF units had 11 TRT units in 2006; low penetration due to:

- Operational barriers (procedural problems with plant directly using TRT-generated electricity, and/or selling to the grid)
- Financial barriers (not sufficient funds to install TRT, particularly for smaller plants. e.g. QuingGang plant in Shandong installed 2 TRT in 2005; cost equal to 59% of the total 2005 annual profits of 169 million yuan. N.B. New BF in China costs 400 million yuan)

McKinsey’s view of Chinese steel sector BAU outlook (China’s Green Revolution, McKinsey, 2009) i.e. assumptions behind the McKinsey MAC:

- China to pursue advanced BAT technology for new-build already in use in developed countries (EU, Japan etc)
- Estimated savings of 330 MtCO₂ by 2030 compared to ‘frozen technology’ baseline incl. TRT; pulverised coal injection (PCI); oxygen-enriched PCI; CDQ plants; process automation; improved use of BFG; replacement of BOF with EAF as scrap supply increases. Most are energy-saving options at negative long-term cost.
- China’s National Climate Change Program emphasizes need to use most of these measures.
- With measures, energy efficiency to improve from 750 kg SCE/t steel (frozen technology) to 570 kg SCE/t steel (baseline) by 2030. Note: Government target is 700 by 2020.
• Shift from BOF to EAF will result in 200MtCO\textsubscript{2} of savings by 2030 (however, lack of steel scrap is major barrier in China\textsuperscript{58}).

• **EAF estimated to account for 30% of total China steel production in 2030 (scrap supplies to grow from 70 Mt in 2005 to 290 Mt in 2030).**

• Above assumes that EAF capacity will increase to perfectly exhaust scrap availability; assumes proactive planning and management from government.

• Better utilisation of BFG assumes to achieve savings of 40MtCO\textsubscript{2} by 2030. Average utilisation rate assumed to be 85%; China BAT appears to be 93%. By 2030, utilisation assumes to be 95% due to closure of sub-scale steel mills.

• **With abatement measures, China could reduce carbon intensity from 2.7 tCO\textsubscript{2} / t steel in 2005 to 1.7 tCO\textsubscript{2} / t steel in 2030.**

There remains a range of technologies and plant sizes in China. The difference between the best plant and laggards is striking, as shown in Table A4. Despite recent improvements, steel making in China remains about 20% less efficient than in Japan in 2003 (Jiang and Xiulian 2006). Diffusion of some key technologies remains low, as shown in Figure A18.

Work by Tsinghua University in 2008 confirms that investment costs are significant for key technologies in China:

• CDQ: 150-300 M Yuan ($22-45 million)

• TRT: 30-50 M Yuan ($4.5-7.5 million)

• Waste Heat Recovery at sintering plant: 40-50 M Yuan ($6-7.5 million, if sintering plant> 90m\textsuperscript{2})

• BOF with negative energy consumption: 20 M Yuan ($3 million)

$3.4 billion investment required to achieve China abatement potential (143 MtCO\textsubscript{2}) i.e. $24/tCO\textsubscript{2} average cost of abatement (Note: MAC study excludes CCS and other abatement options).

**Table A4** Net Energy Use in Chinese Steel Making

<table>
<thead>
<tr>
<th></th>
<th>Sintering</th>
<th>Coking</th>
<th>Blast furnace</th>
<th>Oxygen steel (BOF)</th>
<th>Electric steel (EAF)</th>
<th>Rolling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GJ/t</td>
<td>GJ/t</td>
<td>GJ/t</td>
<td>GJ/t</td>
<td>GJ/t</td>
<td>GJ/t</td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>Average</td>
<td>2.0</td>
<td>4.3</td>
<td>13.3</td>
<td>0.8</td>
<td>6.7</td>
</tr>
<tr>
<td>2003</td>
<td>Average</td>
<td>1.9</td>
<td>4.1</td>
<td>14.2</td>
<td>0.7</td>
<td>6.2</td>
</tr>
<tr>
<td>2004</td>
<td>Average</td>
<td>1.9</td>
<td>4.2</td>
<td>13.7</td>
<td>0.8</td>
<td>6.2</td>
</tr>
<tr>
<td>2004</td>
<td>Advanced</td>
<td>1.5</td>
<td>2.6</td>
<td>11.6</td>
<td>-0.1</td>
<td>4.3</td>
</tr>
<tr>
<td>2004</td>
<td>Laggard</td>
<td>3.2</td>
<td>6.7</td>
<td>17.3</td>
<td>2.2</td>
<td>9.5</td>
</tr>
</tbody>
</table>


The trade press suggests most recent iron & steel plants are large-scale BF, deploying BAT such as PCI, CDQ, (some) TRT, etc. All the evidence available to the study team suggests that new Chinese plant is already at world BAT levels. There is little evidence of new-build EAF; many planned expansions/new plants appear to have been scrapped/deferred.

\textsuperscript{58} Although this barrier will reduce as China develops more scrap becomes available as assets from the past are scrapped.
A5.3 Projections of Carbon Intensity

Recently, researchers (Wang Ke, 2006) have developed a LEAP-China model, based on the LEAP (Long-range Energy Alternatives Planning system) software that contains energy demand, energy cost, CO₂ emissions etc. Wang Ke constructed the Leap-China model for China’s steel and iron industry from 2000-2030 with CO₂ emissions scenarios. Table A5 shows projections of emissions intensity under three scenarios. Each shows a major reduction in intensity compared to the current average of 2.68 tCO₂/t steel.

Table A5 CO₂ emission per unit steel under different scenarios (Wang Ke, 2006)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2000</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark scenario</td>
<td>2.68</td>
<td>2.19</td>
<td>1.97</td>
<td>1.83</td>
</tr>
<tr>
<td>Carry out current policy scenario</td>
<td>2.68</td>
<td>1.96</td>
<td>1.80</td>
<td>1.63</td>
</tr>
<tr>
<td>Strengthen energy saving technology</td>
<td>2.68</td>
<td>1.71</td>
<td>1.58</td>
<td>1.48</td>
</tr>
<tr>
<td>policy scenario</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A possible world stock model projection to 2030, incorporating only negative cost options, by the Japanese RIITE (2008) is shown in Figure A19. With China having a major and increasing share of world production, the world stock model is driven strongly by assumptions regarding China.

Looking further ahead, CCS could potentially save around 300 MtCO₂ emissions annually – the challenge is clearly one of implementation.
Table A6  Future potential of capture CO₂ by CCS in iron and steel industry in China

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel output (Mt)</td>
<td>356</td>
<td>480</td>
<td>550</td>
<td>600</td>
</tr>
<tr>
<td>Unit steel CO₂ emission intensity (tCO₂/t steel)</td>
<td>1.7</td>
<td>1.51</td>
<td>1.38</td>
<td>1.28</td>
</tr>
<tr>
<td>Proportion of blast furnace energy consumption in total energy consumption (%)</td>
<td>59</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Large blast furnace share (%)</td>
<td>70</td>
<td>80</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>Steel industry CO₂ emission</td>
<td></td>
<td>720</td>
<td>760</td>
<td>760</td>
</tr>
<tr>
<td>Potential of capture CO₂ by CCS</td>
<td>280</td>
<td>320</td>
<td>340</td>
<td></td>
</tr>
</tbody>
</table>

Note items 1-4 are estimated. The steel CO₂ emission intensity come from the literature [Bai Bing (2006), Steel Industry Yearbook 2007]

A5.4 Conclusions
If Chinese policy and plans are implemented, we will see major reductions in carbon intensity from the current value of 2.68 tCO₂/t steel:

- Evidence strongly suggests that new plant is already built to world BAT standards;
- Improvements to existing, non-obsolete plant are limited by investment capital;
- The closure of obsolete plant should be undertaken as rapidly as possible. It is unclear how a Sectoral Approach may help this process;
- China needs to improve its scrap recycling rate in order to be able to build EAF plant and reduce its average carbon intensity;
- There is significant CCS potential which needs to be developed and incentivised.
A6  **Indian Policy and Plans**

The World Steel Association indicated that India’s production was 55.2 Mt steel in 2008, i.e. around 10% of that in China. Blast furnaces, at 22 Mt, made up only 40% of the total. 1 Mt of obsolete open hearth furnaces remain, with almost 60% of the total is made up of EAF. Of this 32 Mt, somewhere over half (15-20 Mt) is from DRI, which is predominantly coal-based.

For India’s generic climate change policy, see Annex C.

A6.1  **Government Policy and Plans**

The Ministry of Steel’s National Steel Policy of 2005 gives as a strategic goal that, “The long-term goal of the national steel policy is that India should have a modern and efficient steel industry of world standards, catering to diversified steel demand. The focus of the policy would therefore be to achieve global competitiveness not only in terms of cost, quality and product-mix but also on terms of global benchmarks of efficiency and productivity. This will require indigenous production of over 100 million tonnes per annum by 2019-20 from the 2004-05 level of 38 Mt.”

The Indian steel sector is projected to add large quantities of new capacity going forward. Indian policy is that this will be using world standard new plant. The Policy indicates that it would expect 60% of new plant to 2020 to be BF/BOF, 33% EAF and 7% other (DRI). There is little guidance within the Policy of what technologies should be used in new plants, but we can expect that the current large companies (who have an international outreach) and the potential new investors will build to world-class standards. Tata Steel’s vision to 2012 is to reduce its emissions below 1.7 tCO₂/t liquid steel.

The Policy focuses on one of the major challenges to India — the need to secure sufficient quantities of coking coal. The majority of Indian coal is of lower quality.

A6.2  **Current and Future Technology**

McKinsey projects 300 Mtpa of production in 2030. They foresee a potential reduction from 735 MtCO₂ emissions in the reference case to 573 MtCO₂, i.e. a 22% reduction to an average of 1.9 tCO₂/t steel. Figure A20 gives details – approximately half is expected to come from a general, year-on-year improvement in process energy efficiency. Shifting from BF/BOF to EAF (5% shift) and to natural-gas fired DRI (7%) are the next largest reduction items.

Figure A20  Emissions Reduction Potential in 2030 (McKinsey)
A6.3 Conclusions

- Some new plant is likely to be built to world standards, others below;
- Replacing at least some of the projected new build of Coal-fired DRI with Blast Furnaces would yield significant emission reductions;
- India already has a developed scrap collection sector but increases could allow more EAF plant to be built in preference to BF/BOF;
- Closure of mini producers would yield benefits but will be difficult to achieve. Unlike China, India has no specific policies to make such closures;
- There is no focus on CCS at the present time.

A7 The Scrap Market

The global scrap market supplies 40% of ferrous material used for steelmaking or approximately 450 million tonnes of scrap steel. Scrap steel markets are globally integrated, in that local prices may diverge somewhat but as a rule they converge since buyers can easily access different international markets. About 17% of all scrap steel was traded across international borders in 2002. Steel scrap tends to flow from mature industrialized economies that have large quantities of end of life equipment, such as the USA, the former USSR, Germany, France, the UK and now Japan, to newly industrialized countries such as Turkey, South Korea, Taiwan, Malaysia and China.

Scrap steel is used both in Electric Arc Furnaces (EAFs) and iron ore blast furnaces (BFI) for steel production. EAFs are typically charged with 90% to 100% recycled steel and basic oxygen furnaces can use up to a maximum of about 30% recycled steel. In 2007, BFI production used 31% of all scrap to produce 75% of all steel. EAF used 69% of all available scrap to produce 25% of all steel.

More steel is recycled worldwide annually than all other materials put together, with an estimated 500 million metric tons being recycled in 2008. More than 90% of this material is used in steelmaking. There are two main sources of steel scrap, excess material from steel production and downstream manufacturing and steel that has reached the end of a product’s life. In the United States and Europe, the primary source of obsolete steel scrap is the automotive sector. End-of-life collection rates vary significantly across regions and sectors; however, average steel recycling rates are very high compared to other materials. Estimates of the global weighted recovery rate of steel are indicated in Table A7.

Table A7 Estimated Scrap Recovery Rates (2007)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Recovery Rate 2007 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>85</td>
</tr>
<tr>
<td>Automotive</td>
<td>85</td>
</tr>
<tr>
<td>Machinery</td>
<td>90</td>
</tr>
<tr>
<td>Electric and domestic appliances</td>
<td>50</td>
</tr>
<tr>
<td>Weighted Global Average</td>
<td>83</td>
</tr>
</tbody>
</table>


The recycling rates for appliances and construction steel are expected to increase in emerging industrial countries over the next decade. Given that the average recycling rates are already high it is not expected that scrap level supplies will increase at a significantly greater rate than production in the future.

In most regions of the world the scrap supply industry typically has a pyramidal structure and material is consolidated up a tier of processors. At the bottom of the pyramid there are thousands of collectors in each country or region that gather steel from local sources. A much smaller number of domestic middle merchants gather these materials from the collectors and sort and process the scrap steel. At the top of the pyramid there are a small number of multinational large firms that consolidate the recycled steel and sell it to steelmakers.

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A7.1 Imports and Exports of Scrap Steel

In 2008 approximately 25% of all scrap steel used in steelmaking was imported. Table A8 and Table A9 indicate the largest importers and exporters of scrap steel and compare imports and exports from 2004 and 2008.

Table A8  Largest Importers of Scrap Steel accounting for more than 75% of Global Trade in 2008

<table>
<thead>
<tr>
<th>Country</th>
<th>Imports (millions of tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2004</td>
</tr>
<tr>
<td>Turkey</td>
<td>12.9</td>
</tr>
<tr>
<td>United States</td>
<td>4.6</td>
</tr>
<tr>
<td>Asia (not including China, South Korea, Taiwan, Japan)</td>
<td>10.4</td>
</tr>
<tr>
<td>Commonwealth of Independent States</td>
<td>2.4</td>
</tr>
<tr>
<td>Belgium, Luxembourg</td>
<td>8.4</td>
</tr>
<tr>
<td>South Korea</td>
<td>7.5</td>
</tr>
<tr>
<td>Spain</td>
<td>6.4</td>
</tr>
<tr>
<td>Germany</td>
<td>5.4</td>
</tr>
<tr>
<td>Italy</td>
<td>5.6</td>
</tr>
<tr>
<td>Taiwan, China</td>
<td>3.8</td>
</tr>
<tr>
<td>Africa</td>
<td>0.1</td>
</tr>
<tr>
<td>China</td>
<td>10.2</td>
</tr>
</tbody>
</table>


Table A9  Largest Exporters of Scrap Steel accounting for more than 75% of Global Trade in 2008

<table>
<thead>
<tr>
<th>Country</th>
<th>Exports (millions of tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2004</td>
</tr>
<tr>
<td>United States</td>
<td>11.9</td>
</tr>
<tr>
<td>Commonwealth of Independent States</td>
<td>18.6</td>
</tr>
<tr>
<td>Germany</td>
<td>7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6.8</td>
</tr>
<tr>
<td>France</td>
<td>5.6</td>
</tr>
<tr>
<td>Japan</td>
<td>6.8</td>
</tr>
<tr>
<td>Africa</td>
<td>0.4</td>
</tr>
<tr>
<td>Canada</td>
<td>3</td>
</tr>
<tr>
<td>Netherlands</td>
<td>4.1</td>
</tr>
<tr>
<td>Belgium, Luxembourg</td>
<td>3.4</td>
</tr>
</tbody>
</table>


The estimated use, trade and domestic supply of scrap steel in the European Union in 2004 and 2008 is summarized in Table A10.

Table A10  Estimated Use, Trade and Domestic Supply of Scrap Steel in European Union (2004 and 2008)

<table>
<thead>
<tr>
<th></th>
<th>2004 (millions of tonnes)</th>
<th>2008 (millions of tonnes)</th>
<th>Relative Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports</td>
<td>37.4</td>
<td>47.1</td>
<td>+20.6%</td>
</tr>
<tr>
<td>Exports</td>
<td>39.8</td>
<td>42</td>
<td>+5.2%</td>
</tr>
<tr>
<td>Consumption</td>
<td>109.1</td>
<td>111.3</td>
<td>+2.0%</td>
</tr>
<tr>
<td>Domestic Supply</td>
<td>111.6</td>
<td>106.2</td>
<td>-5.1%</td>
</tr>
</tbody>
</table>

While the consumption of scrap steel in the EU rose by 2% between 2008 and 2004, actual production of steel in the EU fell by 2%. As a result the production of steel from scrap steel increased on average in the EU from 54% in 2004 to 56% in 2008. During the same period there has been a significant increase in imports in scrap steel to make up for a shortage of domestic supply.

A7.2 Prices for Scrap Steel

World prices for steel scrap are set in the US and transmitted through dockside trading. Scrap steel markets have become more closely co-integrated over time, with fewer price differences and any prices changes are quickly transmitted to local markets. There is a short run relationship between demand for steel and scrap steel prices. Typically there is a three month lead between output and scrap steel prices. In the long run price is influenced by process choice among steelmakers (i.e., whether steel is made in EAF or BFI and what percentage of scrap steel is used). The current scrap market looks set to provide growing supplies of scrap to steelmakers at prices that match supply and demand.

Prices for scrap vary depending on the grade of the steel. Figure A21 provides the price of different grades of steel scrap between 2000 and 2008.

Figure A22 indicates US, China, Western Europe and world export steel prices so that they can be compared to scrap steel prices. The price of steel scrap closely follows the price of steel. In general, steel is worth between $200 to $300/tonne more than scrap steel.

Figure A21. US Scrap Steel Prices delivered to Steel Plant (2000 – 2008)

![Graph showing US Scrap Steel Prices](source-url)
A7.3 Drivers of Scrap Steel Market

- The use of recycled steel appears to be limited only by availability and price, not the processing capacity in the world's steel mills.
- Scrap is a commodity market. Although there is no formal futures market for steel scrap, there have been attempts in the past to establish a formal market.
- Steel industries in North America and Europe are highly reliant upon scrap, while industries in Asia, South America and the Middle East use far less scrap. On average approximately half of steel production in Europe and North America is from EAF that predominantly use scrap.
- The rate of recycling of steel globally is already very high (83%), and it is likely that the availability of scrap steel will increase only marginally and keep pace with the increasing demand.
- Implementation of a carbon price increases the value of scrap steel to substitute either coke in the BF process or coal or natural gas in the DRI process. One would expect to see increased consumption of scrap steel for steelmaking in this case, although capital investments to switch steelmaking processes are substantial and these effects may take some time to take effect. The effect observed between 2004 and 2008 in the European Union is that the consumption of scrap steel per tonne of steel produced increased by 4%. How much of this increase is due to the influence of the EU ETS has not been established. The magnitude of the change is in any case relatively low.
- Demand and price for steel is the primary driver for prices in the scrap steel market.

A8 The Coke Market

Worldwide trade in metallurgical coke for steelmaking represented 6% of total demand in 2007. This means that out of the total 525 million tonnes of coke used to produce iron in blast furnaces, 32 million tonnes was imported from outside the country.

Metallurgical coke production is distributed all over the world. Most production worldwide occurs at integrated steel mills where metallurgical coke is further processed into iron at the same site; however, there are also producers that manufacture metallurgical coke from coking coal and then sell it to steelmakers either domestically or internationally. These metallurgical coke producers are often independent facilities and not integrated steel mills. In China, the largest exporter of metallurgical coke, approximately 20% of total metallurgical coke production was from small beehive ovens in 2003. This small and inefficient production was being phased out and likely accounts for a small fraction of total output in
2009 and most output in China is from integrated steel mills or merchant plants. The metallurgical coke output in 2003 was split between 40% from integrated steel mills and 60% from merchant plants.\textsuperscript{60}

**A8.1 Imports and Exports of Metallurgical Coke**

The main exporters and importers of metallurgical coke for steelmaking are outlined in Table A11 and Table A12.

Table A11  Exports of Metallurgical Coke in millions of tonnes (2005 to 2007)

<table>
<thead>
<tr>
<th>Country</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>12.8</td>
<td>14.5</td>
<td>15.2</td>
</tr>
<tr>
<td>Poland</td>
<td>4.1</td>
<td>6.1</td>
<td>6.3</td>
</tr>
<tr>
<td>Russia</td>
<td>2.8</td>
<td>1.8</td>
<td>3.6</td>
</tr>
<tr>
<td>Japan</td>
<td>1.6</td>
<td>2.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.7</td>
<td>0.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Spain</td>
<td>0.6</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1.0</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Bosnia &amp; Herzegovina</td>
<td>0.4</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1.1</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Australia</td>
<td>0.3</td>
<td>0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Egypt</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.0</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.5</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>26.5</strong></td>
<td><strong>29.6</strong></td>
<td><strong>32.5</strong></td>
</tr>
</tbody>
</table>


Table A11 indicates that there are a number of countries that export metallurgical coke that do not have any domestic steel production including Egypt and Zimbabwe.

There is a potential for increased exports of metallurgical coke from a few countries such as Colombia, Russia and Ukraine in the long-term, but in general coke exports are expected to remain relatively stable or decline in the future. Exports from China have remained roughly the same between 14 and 15 million tonnes between 2000 and 2007. However, Chinese exports of Coke are being limited in the future to approximately 12 million tonnes due to tariff restrictions. A new 40% duty on Chinese coking coal and metallurgical coke will limit supply to the international market.

Table A12  Imports of Metallurgical Coke in millions of tonnes (2005 to 2007)

<table>
<thead>
<tr>
<th>Region</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>12.4</td>
<td>12.6</td>
</tr>
<tr>
<td>India</td>
<td>4.3</td>
<td>4.7</td>
</tr>
<tr>
<td>Asia (not including India)</td>
<td>3.1</td>
<td>4.1</td>
</tr>
<tr>
<td>Commonwealth of Independent States</td>
<td>2.2</td>
<td>3.4</td>
</tr>
<tr>
<td>North America</td>
<td>4.5</td>
<td>3.1</td>
</tr>
<tr>
<td>Latin America</td>
<td>1.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Maghreb &amp; Middle East</td>
<td>0.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Africa</td>
<td>0.3</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Total metallurgical coke imports of 12.6 million tonnes to Europe represented 23% of total demand for coke in 2007. This means that Europe is by far the largest importer of metallurgical coke with the highest percentage of coke demand from imports in the world. Many producers of metallurgical coke in Europe exited the market in the last fifteen years because of the low prices and increasing supply of coke from China. Since there is no domestic production the remainder of demand for coke in Europe is met by imports of coking coal. Within Europe, Germany is the largest market in Europe importing more than 4 million tonnes of metallurgical coke.

**A8.2 Prices for Metallurgical Coke**

Between August 2007 and July 2008 the price of metallurgical coke increased dramatically even when compared to the price of steel. Figure A23 provides an indexed cost of coke versus steel and other raw materials. Clearly prices for all inputs collapsed in the financial crisis of 2009 and its aftermath.

Increased prices of metallurgical coke in 2008 indicate a restricted supply on the global market. The basic raw material to make metallurgical coke is coking coal. Figure 2.28 compares the prices of these two commodities.

As can be seen in Figure A24, the pricing relationship between coking coal and coke can vary substantially. In one quarter prices for coking coal and metallurgical coke were on par, however, this is likely a brief market anomaly. In contrast, another quarter shows metallurgical coke value spiking at almost 5 times that of coking coal. On average between 2005 and 2008 metallurgical coke was worth $125 / ton more than coking coal or approximately double the value of coking coal.

**Figure A23 Indexed Pricing for Coke, Steel and other Raw Materials (2007-2008)**

![Indexed Pricing Chart](source)

**A8.3 Drivers of Metallurgical Coke Market**

- There is a global market for Metallurgical coke. Production and export markets are located all around the world.
- In regions such as Europe with no domestic production of coking coal, large imports of coking coal from Australia, Canada and the United States are required to meet the demand for coke. Europe currently meets approximately 23% of demand for metallurgical coke with imports. There is no
trend in import data to suggest that the European Union has increased imports of metallurgical coke to substitute coking coal.

- Metallurgical coke exports are not expected to expand significantly given the restrictions on the largest export market in China and the limited potential to increase exports from other countries.
- Most countries are currently able to substitute coking coal with metallurgical coke in their steelmaking processes. A carbon price implemented in a specific region that did not restrict importation would increase the value of metallurgical coal imports as it would displace emissions to the country of origin. It is likely that this region would capture market share from other regions with no carbon price forcing them to expand their imports of coking coal rather than affect the overall production of metallurgical coke. A carbon price would also in the long-term increase the market share of less carbon intensive steelmaking processes, including DRI and EAF.
- The demand and price for steel is the main driver for the price of metallurgical coke.
- Market variability in prices can be significant due to restrictions in supply and changes in steel production output.

Figure A24  Pricing for Coke and Coking Coal by Quarter (2005-2008)

Annex B: China’s Climate Change Policies

<table>
<thead>
<tr>
<th>Climate Change Policies in China</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>National Climate Change Program:</strong> Energy generation/use</td>
</tr>
<tr>
<td>- Reduce energy consumption per unit GDP by 20%</td>
</tr>
<tr>
<td>- Accelerate institutional reform</td>
</tr>
<tr>
<td>- Foster bioenergy and renewables, including wind, solar, geothermal and tidal</td>
</tr>
<tr>
<td>- Develop hydropower resources</td>
</tr>
<tr>
<td>- Promote nuclear power</td>
</tr>
<tr>
<td>- Ultra-supercritical coal, methane bed, and mine methane technology</td>
</tr>
<tr>
<td>- R&amp;D for efficient coal mining, oil and gas exploration and use technologies</td>
</tr>
<tr>
<td>- Improve efficiency standards, programs and implementation</td>
</tr>
<tr>
<td>- New financing mechanisms and tax policies to promote energy savings</td>
</tr>
<tr>
<td>- Most efficient technologies for iron and steel; cement; oil and petrochemical; agricultural machinery industries</td>
</tr>
</tbody>
</table>

On June 5th, 2009, China’s highest council announced that the government would step up efforts to shut down old, inefficient power plants and factories, and increase spending on renewables and efficiency.

**Making large enterprises more efficient**
The Top 1000 Energy-Consuming Enterprises Program sets energy-saving targets for China’s largest industries. The program was responsible for an impressive two-thirds of China’s energy efficiency gains in 2006 and half of the gains in 2007. The program is on track to reach its goal for 2010.

**Taxes on petroleum**
In January 2009, China increased the tax on gasoline from 11 cents per gallon to 55 cents per gallon and the tax on diesel rose from 6 cents per gallon to 44 cents per gallon.

**Required green government procurement.**
In April 2009, China’s highest government body, the State Council, mandated that governments at all levels buy more eco-friendly products, evaluated on the basis of energy consumption, noise, pollution emissions, product design, use of recycled materials and minimization of hazardous materials.

**Renewable energy target of 15% by 2020:**
- Set two wind power goals in 2005 — 5 GW by 2010 and 30 GW by 2020
- Grow solar: newly enacted subsidy of approximately $2.80 per watt of installed power is evidence of the Chinese government’s commitment to developing a domestic solar market
- Diversified domestic energy sources: Sources such as organic and municipal waste and methane gas captured from coal mining are playing increasingly important roles in energy production in both the public and private sectors. In 2007, the national government added a 4 cent feed-in tariff to encourage biomass use in power production with a goal of reaching 30 GW of biomass power by 2030. This is in addition to the use of biomass directly in industrial boilers, which is already in place in 1600 factories. Moreover, over 50 Chinese cities run waste-to-energy power or district heating plants. China’s national goal is to process 30% of total municipal waste into energy by 2030.16

**Infrastructure for green development**
One third of China’s stimulus package is focused on infrastructure that will promote energy efficiency
- $90 billion in rail construction in 2009
- This new investment comes after considerable upgrades over the last ten years, including an upgrade that increased rail shipping capacity by 18% in 2007. In addition, public transportation in at least 15 major cities is being significantly improved.20 For example, Beijing added three new subway lines, a light-rail connecting downtown and the airport, and bus rapid transit.

- $160 billion over two years for electric grid construction
- Made new buildings more energy efficient through clearer regulations and increasing enforcement.

**Cleaner Production Promotion Law (2002)**
Requires local governments to develop and implement cleaner production plans and periodically release pamphlets and guidebooks with instructions. Encourages research and development of cleaner technologies and processes and the dissemination of information and awareness about clean production through educational programs and television/media outlets. Formulates tax incentives and otherwise supports the research and development of clean technologies. Requires technological upgrades and certain standards in building, construction and production. Established demonstration
programs for pollution remediation in ten major Chinese cities, and designated several river valleys as priority areas.

**Conversion of Exhaust Heat and Pressure (2006)**
- Within the 11th Five Year Period (2006 - 2010), the Chinese government has mandated the efficient use of exhaust, pressure and heat from mining and industrial processes. Iron and steel enterprises will apply coke dry quenching (CDQ) and power generation through the pressure difference in blast furnace, renovate all blast furnace gas power generation and implement converter gas recovery to save 2.66 million tons of standard coal;
- install each year 30 sets of medium-and-low-temperature exhaust-heat power generation equipment in concrete production lines with a daily yield of 2,000 tons;
- exploit ground coalbed gas (CBG), extracting and draining gas in ground mined-out areas, discarded mines and below the grand surface, to realize an annual gas application of one billion cubic meters, equivalent to saving 1.35 million tons of standard coal.

**Design Standards (revision 2005-6)**

**Electricity price increase (2006)**
China’s top pricing and tax decision-making group has developed a pricing system for electricity generated by renewable energy. The plan requires raising the tariff - the set price at which generators of electricity can sell their power to grid companies. The rate increase will vary by region depending on the level of economic development. The customer will be paying the additional cost of producing RE.

**End-Use Energy Efficiency Programme (EUEEP) (2005)**
EUEEP is part of a 12-year government plan to dramatically improve the efficiency of China’s major energy users: commercial and residential buildings, heavy industries such as iron, steel, cement, and petrochemicals. The EUEEP is designed to support develop and implement a comprehensive system of policies and regulations for energy conservation. These will range from technological innovations to creation and revision of design codes to the development of training materials and energy conservation guidelines for architects, engineers, and industrial managers to improve the efficiency of industrial equipment such as electric motors and boilers, household, appliances such as refrigerators and washing machines, as well as office automation equipment. The UNDP and the GEF, in partnership with government agencies, research institutes, bilateral donor countries, non-governmental organizations, and enterprises, will also help introduce and test new technologies, methodologies, and market-based mechanisms and tools.

**Energy Conservation in Government (2006)**
To improve the energy efficiency of government institutions during the 11th Five-Year Period, China required several reforms of government operation:
- During reconstruction of government buildings - including heating, air-conditioning and lighting systems - 20 percent of the total construction area must meet the national building energy efficiency standard.
- Government procurement must promote high-efficiency products and publish their list.
- Government vehicle purchases must focus on low-oil-consuming vehicles.

With these mandates, the Chinese state aims to save energy by 10% per unit construction area and per capita, relative to 2002.

**Enhanced Efficiency Monitoring and Auditing: Development of Efficiency Centers (2006)**
Within the 11th Five-Year Period, China aims to boost the capability of provincial efficiency monitoring centers of provinces and principal energy-consuming industries. Such support appears as renovation of monitoring equipment, personnel training and promotion of contractual energy management. LIABLE under federal law, the centers of monitoring and auditing must develop and provide package services of efficiency diagnosis, design, financing, renovation, operation and management, for enterprises, government institutions and schools.

**IFC’s China Utility-Based Energy Efficiency Finance program (2006)**
CHUEE supports marketing, development and equipment financing services to energy users in the commercial, industrial, institutional and multi-family residential sectors to implement energy efficiency projects in China. CHUEE brings together financial institutions, utility companies, and suppliers of energy efficiency equipment. The program is expected to promote energy efficiency, reduce pollution
and greenhouse gas emissions, and expand lending to small and medium enterprises in China

**Medium and Long Term Energy Conservation Plan (2004)**

Plan of Energy Conservation aims to push the whole society towards energy conservation and energy intensity reduction, to remove energy bottlenecks, to build an energy saving society, and to promote sustainable social and economic development. In this plan, detailed energy conservation targets were set up. Key actions and comprehensive policy measures were put forward such as the Ten key projects for Energy Conservation. The programming period is divided into the Eleventh Five Year Plan period running to 2010 and the period from 2010 to 2020. The energy conservation objectives and the focus of development by 2010 are essentially planned, whereas the objectives stated for 2020 are proposed.

Specifically: Guidelines for Rural Hydropower plan to increase its installed hydropower capacity by 15 million kilowatts to supply electricity for 10 million rural residents from 2006 to 2010 by constructing 400 hydropower driven counties; Guidelines for Transport plan six railways for passenger transportation, including one between Beijing and Shanghai and five inter-city railways, 14 expressway by 2010; Plan for Energy Conservation aims to reduce energy consumption per capita by 20% in 2010, compared to 2005


The Plan has specific targets for power generation from renewable sources. The target for 2010 (60 GW) will represent about 10 percent of China’s total installed power generation capacity. The equivalent figure for 2020 (Target: 121 GW) is about 12 percent. China will also pay considerable attention to the development of RE heat sources and to liquid biofuels, etc. Overall, China’s use of renewable energy is expected to increase to 20,000 PJ/year by 2020 - 17 percent of the country’s projected total energy consumption

**National Energy Strategy (2005)**

Continued improvement in energy efficiency at the same rate as the past 20 years. Rapidly expand the use and supply of Natural Gas. Decrease the reliance on Coal to less then 60% of total energy use by 2020. Increase the use of clean coal technologies for power generation. Introduce coal liquefaction for transport fuels. Substantially increase reliance on hydropower. China aims to have 200 to 230GW of hydroelectricity by 2020. Install up to 40GW of nuclear power capacity by 2020. The NESP’s target for renewable energy is an additional 90 to 100GW of capacity by 2020, including 60 to 70GW of small scale hydropower, 20GW of wind power, 1GW of biomass-fired electricity, and small increases in solar, geothermal, ocean and tidal energy. Accelerated development and large scale deployment of combined heat and power (CHP, or cogeneration).

**Program of Action for Sustainable Development (2007)**

This program is a follow-up of the White Paper on China’s Population, Environment, and Development in the 21st Century. It acknowledges progress made in the last decade including economic and social developments and capacity building, and also upcoming challenges. To deal with these challenges, the program suggests improving research and investment in sustainable development, improving legislation and supporting institutions, and strengthen international cooperation. A priority includes:

- Economic development: industrial restructuring, regional and small-town development, and economic globalization

**Strategic Plan for Industrial Efficiency (2006)**

Within the 11th Five-Year Period, China’s strategic plan for energy efficient industrial processes involves equipment renovation and the design and implementation of process optimization and management measures. Targetting the metallurgical industry, petrochemical industry, and chemical industry, the Chinese state aims to improve energy efficiency and industrial competitiveness to "the highest level or close to the world’s front-runners.

**Tax on high-sulfur coals**

In an effort to scale down coal consumption and to spur switching to cleaner burning fuels, Beijing has introduced a tax on high-sulfur coals. Other efforts include establishing 40 "coal-free zones" in an attempt to phase out coal from the city center, and formulating plans to construct natural gas pipelines.

**Taxation incentive policy for High Energy-Efficiency products (2007)**

NDRC and the State Administration of Taxation (SAT) will jointly issue the taxation incentive policy for High Energy-Efficiency products.
Annex C: India’s Climate Change Policies

<table>
<thead>
<tr>
<th>Climate Change policies in India</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>National Action Plan on Climate Change (NAPCC):</strong> Energy generation/use</td>
</tr>
<tr>
<td>• Increased deployment of solar PV; 1,000 MW of concentrating solar thermal power</td>
</tr>
<tr>
<td>• Energy efficiency in industries, small enterprises, energy production, residential sector</td>
</tr>
<tr>
<td>• Promotion of ESCOs and retrofits</td>
</tr>
<tr>
<td>• Regulate power tariffs for irrigation</td>
</tr>
<tr>
<td>• Retire or rehabilitate 10,000 MW old capacity</td>
</tr>
<tr>
<td>• RD&amp;D of supercritical coal</td>
</tr>
<tr>
<td>• Promote nuclear power (closed cycle technology)</td>
</tr>
<tr>
<td>• Exploit hydropower potential (large, medium, micro)</td>
</tr>
<tr>
<td>• Explore dynamic minimum renewables purchase standard starting in 2009-10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The main objectives of the Programme are: to accelerate the promotion of setting up of projects for recovery of energy from urban wastes; to create conducive conditions with a fiscal and financial regime, to develop, demonstrate and disseminate utilisation of wastes for recovery of energy; and to harness the available potential of MSW-to-energy by the year 2017.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>APP partners have agreed to work together and with private sector partners to meet goals for energy security, national air pollution reduction, and climate change in ways that promote sustainable economic growth and poverty reduction. The Asia-Pacific Partnership on Clean Development and Climate is an innovative new effort to accelerate the development and deployment of clean energy technologies. The APP has a number of projects in member countries designed to implement or improve new technologies, better policies, and mutual cooperation. In addition to renewable energy, the APP focuses on manufacturing sectors like steel and cement.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coal Transport Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricts the transportation of unwashed coal to less than 1,000 kilometers.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electricity Act (2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allows liberty to operate and maintain a generating station without obtaining a license if it complies with the technical standards relating to connectivity with the grid, except for hydro. Creates liberal framework for power development, facilitates private investment. Sets stringent provisions for controlling theft of electricity. Mandates creation of Regulatory Commissions to determine retail tariff.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>This policy outlines the challenges that India faces as it develops and must generate and provide increasing amounts of energy. Measures include addressing energy security by acquiring abundant supplies of coal and gas, and increasing hydro and nuclear power. India seeks to improve energy efficiency by reducing energy intensity across many sectors including mining, electricity distribution, transportation, industry and building construction. The policy also outlines methods to promote renewable energy and increase R&amp;D.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Incentives for biogas plants (2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The government is giving financial incentives to provide fuel and improve sanitation by developing biogas plants. The amount of assistance varies in each region, and also includes subsidies for maintenance, repairs, and linking to plants with sanitary toilets.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Campaign is realized through print and electronic media focusing on creation of energy-users awareness on energy savings opportunities, which can significantly reduce the need for additions of new energy supply system in coming years. The campaign includes initiatives that will address the use of energy in industrial, commercial, and agricultural sectors, as well as households and educational institutions. The objective of the campaign is to reduce energy cost by reducing demand for electricity, as well as increasing efficiency of electricity generation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>National Electricity Policy (2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2005 the Government of India put out the National Electricity Policy as required by the Electricity Act of 2003. The National Electricity Policy outlines a plan for rural electrification increased generation capacity. The policy states that “maximum emphasis” would be put on the development of hydro power. Use of thermal power could be made cleaner by using low-ash coal, improving lignite mining, and increased use of natural gas and nuclear power. The policy also sets recommendations for improving the power grid with better transmission and distribution of power. It also calls for the use of the most efficient technologies and more funding for R&amp;D. India also seeks to create a more competitive energy sector to increase private...</td>
</tr>
</tbody>
</table>
sector participation. Finally, the Policy emphasizes the need for conservation and demand-side management including a national awareness campaign.

<table>
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<tr>
<th><strong>National Environment Appellate Authority Act (1997)</strong></th>
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<tbody>
<tr>
<td>An Act to establish a National Environment Appellate Authority to hear appeals regarding restricting certain areas. In these areas industries, operations or processes are banned or are subject to certain safeguards under the Environment (Protection) Act</td>
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<th><strong>National Environment Policy (2006)</strong></th>
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<td>The National Environment Policy aims at archiving: Efficiency Improvement and Conservation of Critical Environmental Resources, Livelihood Security for the Poor, Integration of Environmental Concerns in Economic and Social Development.</td>
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<th><strong>Subsidies for Solar Power (2008)</strong></th>
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<tr>
<td>India will subsidize solar power plants to the amount of 12 rupees (30 cents) per kilowatt hour. This plan will last for five years, and is expected to generate 10 billion rupees ($253.7 million) in private investment.</td>
</tr>
</tbody>
</table>
Climate Strategies aims to assist governments in solving the collective action problem of climate change. It connects leading applied research on international climate change issues to the policy process and to public debate, raising the quality and coherence of advice provided on policy formation.

We convene international groups of experts to provide rigorous, fact-based and independent assessment on international climate change policy. To effectively communicate insights into climate change policy, Climate Strategies works with decision-makers in government and business, particularly, but not restricted to, the countries of the European Union and EU institutions.

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