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Beyond Copenhagen: mechanisms to finance and deliver GHG emissions reductions in the iron and steel sector in China

Achieving greater energy efficiency and greenhouse gas emissions reductions in the Chinese iron and steel sector

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List of acronyms

BAT Best Available Technology
BAU Business as usual
BF Blast Furnace
BFG Blast Furnace Gas
BOF Basic Oxygen Furnace
BOT Build, operate and transfer
CCGT Combined Cycle Gas Turbines
CCS Carbon Capture and Storage
CD-CR Continuous decaling and cold rolling
CDM Clean Development Mechanism
CDQ Coke Dry Quenching
CER Certified Emissions Reductions
CHUEE China Utility based Energy Efficiency Programme
CISA China Iron and Steel Association
CNIS China Institute for Standardization
CO_2e Carbon Dioxide equivalent
COG Coke Oven Gas
COP Conference of Parties
DNA Designated National Authority
DOE Designated Operational Entities
DSM Demand-side Management
EAF Electric Arc Furnaces
EE Energy Efficiency
EMCA ESCO Committee of China Energy Conservation Association
EPC Energy Performance Contract
ESCO Energy Service Company
ESP Electrostatic Precipitator
ETS Emissions Trading Scheme
EU European Union
GDP Gross Domestic Product
FYP Five Year Plan
GHG Global Greenhouse Gas
GJ Gigajoule
HTAC High Temperature Air Combustion
IEA International Energy Agency
IPPC Integrated Pollution Prevention and Control
IRR Internal Rate of Return
ISO International Organization for Standardization
LDG Basic Oxygen Steel Furnace Gas
MRV Measurement, reporting and verification
MT Million tonnes
NAMA Nationally appropriate mitigation action
NDRC National Development and Reform Commission
NGO Non-governmental organisation
OHF Open Hearth Furnace
OG-IDF Oxygen-converter Gas Induced Draft Fan
PCI Pulverised Coal Injection
RMB Chinese Renminbi
SME Small to Medium-sized Enterprise
SNLT Sector no-lose target
SOE State Owned Enterprise
TRT Top-pressure Recovery Turbine
UNFCCC UN Framework Convention on Climate Change
USD US Dollar
VSD Variable Speed Drives
WSA World Steel Association

Executive summary

The International Energy Agency (IEA) attributes around 19% of global final energy use and a quarter of direct industry global greenhouse gas (GHG) emissions to steel production, equivalent to 3% of global emissions. The Chinese iron and steel sector is the largest in the world, producing over 520 million tonnes in China in 2009 – almost half of all global production – and of profound importance to China's economy. According to Chinese national statistics, smelting and pressing of ferrous metals contributed over 7.7% of gross domestic product (GDP) in 2007 (RMB 1.92 trillion) and employs over three million people. In the long term, demand for steel in China is expected to rise in line with economic growth.

The Chinese iron and steel sector is thought to be more energy- and carbon-intensive than in other countries (though data availability issues make it difficult to calculate the exact energy efficiency of the sector), presenting an economic risk if restrictions on international trade are made on the basis of GHG emissions. If the Chinese sector, which is dominated by large state owned enterprises, cannot adapt to produce steel with significantly reduced carbon intensity, then it could be at an economic disadvantage.

This report is the culmination of a study to investigate options for achieving greater energy efficiency and greenhouse gas emissions reductions in the Chinese iron and steel sector, and to explore technologies and international financing mechanisms that could assist the sector to adapt to the demands of a low carbon global economy.

Domestic and international emissions reductions policies

China's Government is already taking actions to reduce emissions from iron and steel production. Policies include phasing out small inefficient blast furnaces (BF) and consolidation of smaller plants into larger, more efficient integrated steelworks. In July 2009, a three-year moratorium was enforced limiting construction of new plants and expansion to address production overcapacity, which stood at 24% in 2008. The 11th Five Year Plan (FYP) energy intensity reduction target of 20% has provided a domestic stimulus to save energy. In the run up to the Copenhagen Conference of Parties (COP) in December 2009, the Chinese Government announced a domestic carbon emissions intensity reduction target of 40 to 45% by 2020. It is not yet clear how this will affect steel production and GHG emissions. Although, it is unlikely there will be an absolute emissions cap, this policy could be the main driver for future reductions..

The Copenhagen Accord commits developing countries to nationally appropriate mitigation actions (NAMAs) to be proposed in 2010 (including relevant technology, finance and necessary capacity building support). NAMAs could be financed with domestic or international funds if eligible. Internationally-financed measures may be subject to international measurement, reporting and verification (MRV). It is not yet clear if any NAMAs will target the Chinese steel sector.

Financing emissions reductions in the Chinese iron and steel sector

The Clean Development Mechanism (CDM) has been influential in driving emissions reductions in China's steel industry. Over RMB 13 billion has been invested in China in 21 registered projects achieving emissions reductions of 12.5 million tonnes CO_2e per year. Typical technologies include top pressure recovery turbines, coke dry quenching and large scale waste heat and gas recovery. CDM implementation is slowing as many of the largest opportunities have been developed, and smaller volumes make registration time and costs prohibitive. However many direct opportunities for improving efficiencies and reducing emissions within the production process remain. In particular, smaller scale projects utilising surplus combustible gas, heat and pressure can have attractive returns. Although financing is available for these projects, in the form of bank loans, ESCO (Energy Service Company) finance and equipment leasing, many iron and steel companies are not willing or able to access this capital. Chinese banks generally lack the capacity to appraise such investments, and projects in the sector tend to be too large and complex for the ESCO model to work. Paybacks and capital costs are typically too high for leasing, and the perceived risk is high. Certain technologies are too expensive and are untested in China. Initiatives such as the IFC's China Utility based Energy Efficiency Programme (CHUEE) are aimed at overcoming these barriers.

New financial mechanisms for promoting further emissions reductions

As part of ongoing international climate change negotiations, *sectoral approaches* have been proposed as an evolution of CDM. These aim to help governments and enterprises in developing countries finance further emissions reduction projects, and pave the way to adopting binding targets in the future. Options apply policy, project or technology-based targets to entire sectors to encourage greater investment in clean technologies and sector-wide improvements. Options discussed in this report include crediting or trading based on absolute emissions, emissions intensity or technology penetration targets. Sectoral crediting mechanisms could bring financial benefit to China's iron and steel sector by setting a no-lose target, generating financial incentives for companies who surpass targets, for example. Consultation carried out for this project found that an approach which focuses on technology targets is likely to be favoured over other potential mechanisms, as it is perceived to be more straightforward to implement and enforce, however some emissions reduction potential would be lost under this approach.

Although Chinese companies may ultimately benefit from participation in sectoral mechanisms, uncertainty over international governance and concerns surrounding local implementation capacity mean that it is difficult to determine which approach would be most appropriate for China. Any new mechanism should maintain a strong incentive to private sector companies in the sector but should not only be driven by sales of "offset" carbon credits to developed countries. The system must be designed so that emissions reductions that are close to business as usual – such as those developed under CDM – are funded by the companies or Government itself rather than by offsets. This will require a sector-wide baseline to be set, which is likely to be an emissions intensity metric and so needs extensive high quality data on both emissions and production, as well as a tightly defined sector. Barriers exist including data availability, agreed sector and product definitions, and metrics to calculate carbon intensity of products.

Recommendations

This report concludes with the following recommendations for policy makers under four headings:

Mechanisms and incentives

- Pilot a domestic GHG emissions trading scheme, drawing on international experience from the EU.
- Test the use of emissions intensity targets and incentives for the iron and steel sector. A sector no-lose target could be tested on a voluntary basis, with companies who surpass the target eligible for an incentive funded through international sector-based offset mechanisms, for example.
- Streamline the CDM to accelerate investment in emissions reductions.

Finance

- Consider policies to improve access to long term commercial loans for steel companies and ESCOs. Initiatives such as CHUEE could be extended, for example.

Awareness

- Encourage the Iron and Steel Association and related organisations to play an active role in raising awareness among steel companies on topics such as carbon targets, NAMAs and MRV.
- Pilot selected state of the art technologies which are not yet commercially proven or widely available in China.
- Encourage engagement of iron and steel companies with voluntary disclosure projects.

Services

- Enact laws to support ESCO business models to reduce risk and uncertainty.

1 Introduction

"Global climate change has a profound impact on the existence and development of mankind and is a major challenge facing all countries… We will step up effort to develop green economy, low-carbon economy and circular economy, and enhance research, development and dissemination of climate-friendly technologies… Out of a sense of responsibility to the world ... China has taken and will continue to take determined and practical steps to tackle this challenge." Chinese President Hu Jintao

1.1 Overview

In the run up to the United Nations climate change conference in Copenhagen (COP 15) in December 2009, China announced a domestic emissions intensity reduction target of 40 to 45%. Despite the failure of the conference to agree binding emissions targets among developed counties and explicit commitments from developing countries to mitigate climate change, beyond the Kyoto protocol and post-2012, the Copenhagen Accord was noted by the UN. China was a key signatory to the Accord, in which all parties agreed to submit in 2010 a list of Nationally Appropriate Mitigation Actions (NAMAs).[1] The result of this process could significantly impact those nations and industries which emit high levels of greenhouse gases, in particular China and the iron and steel sector.

This report presents options for achieving greater energy efficiency and greenhouse gas emissions reductions in the Chinese iron and steel sector, and so help mitigate global climate change. Existing technologies and financing mechanisms are described and the potential benefits from *sectoral approaches* explored. The report is organised into five sections as follows.

1. **Introduction** – including a summary of global climate change action and negotiations.
2. **The Iron and steel sector in China** – an overview of the sector with respect to production volume, energy consumption, current GHG emissions and the main causes of higher than necessary emissions.
3. **Existing financing mechanisms for energy efficiency and emissions reductions,** and barriers and opportunities – summarising existing financing mechanisms for energy saving technologies and barriers to these mechanisms, including the Clean Development Mechanism (CDM).
4. **Sectoral approaches to incentivise emissions reductions**– a summary of sectoral approaches proposed by developed countries to move on from CDM to incentivise further investment and emissions reductions in developing countries using sector-based mechanisms. The various options under discussion are appraised in terms of their potential benefits, costs and barriers to their application in the Chinese iron and steel sector.
5. **Recommendations** – guidelines and suggestions for policy makers, iron and steel enterprises and financial institutions to promote greater emissions reductions activity.

   Glossary – including descriptions of the best available technology (BAT) for reducing GHG emissions and financing mechanisms available to Chinese steel companies.

[1] *NAMAs were introduced in the Bali Action Plan in response to calls for enhanced national and international action on mitigation of climate change, including consideration of:*

i) Measurable, reportable and verifiable nationally appropriate mitigation commitments or actions, including quantified emission limitation and reduction objectives, by all developed countries, taking into account differences in their national circumstances;

ii) Nationally appropriate mitigation actions by developing countries in the context of sustainable development supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner.

The Copenhagen Accord states that Non-Annex I Parties will identify climate change mitigation actions (NAMAs) by 31 January 2010 (although this is a "soft" deadline). NAMAs seeking international support will be recorded in a registry along with relevant technology, finance and capacity building support.

This report aims to inform negotiators, policy-makers and other stakeholders involved in discussions following COP 15.

1.2 Global climate change action and negotiations

The UN Framework Convention on Climate Change (UNFCCC) was agreed in 1992 and is the corner stone of much of the international effort to tackle global emissions today. As part of the process of securing a strong international commitment to reduce emissions post 2012, the Bali Action Plan was agreed in December 2007. The Bali Action Plan stipulates that actions will be required by developing countries that were not committed to sovereign action under the Kyoto Protocol, although these actions will be true to the UNFCCC and so in line with countries' "common but differentiated responsibilities and capabilities".

Developing countries have played a role in global mitigation efforts under the Convention by providing cost-effective offsets to aid developed countries to achieve their reduction targets. This has formed the basis of the international carbon market through the CDM.

A key challenge in the on-going negotiations is therefore the need to develop mechanisms that allow for a pathway for countries to move from this role in offsetting to a future regime where they contribute to global greenhouse gas mitigation through domestic reductions that are supplementary to the emissions targets of richer nations, as well as supporting developing countries in making their transition and accelerating this process. Any solution needs to enable them to engage in a more concrete way than with the international frameworks that exist.

Tackling emissions on a sector by sector basis across the economy is one way this could be achieved, with the added advantage of immediate enhancement of the international carbon market to allow developed countries to adopt stricter targets. Furthermore, accounting for emissions on a sector basis could facilitate the recognition of voluntary actions by developing countries in the form of NAMAs, which could either be sold as international offsets or claimed as the host-country's own effort in emissions reductions.

Many international regulations are already managed on a sectoral basis, for example pollution limits on cars and safety standards in particular industries. European climate change policy already takes a partly sectoral approach in that the EU Emissions Trading Scheme (EU ETS) focuses only on certain industrial sectors and caps are allocated on a sector basis within countries. Considering emissions from sectors on a trans-national basis outside of Europe is simply an extension of this concept into the international arena and therefore makes sense as the world looks forward and sets about determining how to develop and implement the ideas and frameworks that were discussed at Copenhagen COP 15.

2 Iron and steel sector in China

- The Chinese iron and steel industry is the largest in the world, with over 520 million tonnes made in China in 2009, accounting for almost half of all global production.
- Growth in the sector is expected to level off over the next three years given the high levels of over capacity in existing plants. Domestic demand for steel will rise steadily in line with projected GDP growth.
- Steel production accounts for about 19% of final energy use and about a quarter of direct GHG emissions from the industrial sector. This is roughly 3% of global GHG emissions.
- The relative energy use of an iron and steel plant is affected by technology type, plant size and quality of raw materials. China's steel sector is more energy intensive than some other countries.
- Over 13 billion RMB has been invested in 21 registered CDM projects in the Chinese steel sector, achieving estimated emissions reductions of 12.5 million tonnes CO_2e per year. However, many opportunities for improving efficiencies and reducing emissions remain.

2.1 Overview

China's crude steel production in 2008 reached 502 million tonnes (mt), an increase of 2.6% on 2007. Production volume in China has more than doubled within five years, from 222 mt in 2002 (World Steel Association 2009). In the first nine months of 2009, China produced almost 420 mt accounting for 49% of total world production over this period (WSA 2009). Utilisation of the sector's production capacity in 2008 was at 76% and is expected to decrease to 72% in 2009 (European Union Chamber of Commerce in China 2009).[2] In reaction to this over capacity the Chinese Government instigated in 2009 a three-year moratorium on applications to expand production or begin construction of new facilities. On the demand side, in the longer term, China is still in the process of industrialisation, urbanisation and structural upgrade. A steady growth in the domestic demand for steel is expected to remain unchanged. China's apparent steel use in 2009 is expected to increase by 19% to reach 526 mt so that China will account for 48% of world steel apparent use. Without this rise in demand in China, world steel demand would have fallen by almost a quarter.

2.2 Steel industry energy use and greenhouse gas emissions

The global iron and steel industry accounts for about 19% of final energy use and about a quarter of direct GHG emissions from the industrial sector, roughly 3% of global GHG emissions, mainly CO_2 (IEA, 2008). The high level of GHG emissions is mostly due to heavy reliance on coal consumption in the production process.

The iron and steel industry has achieved significant efficiency improvements in the past twenty-five years, reducing the energy and carbon intensity of products. Increased recycling and higher efficiency of energy and materials have been mainly responsible for this improvement. Most integrated steel works utilise either electric arc furnaces (EAF) or basic oxygen furnaces (BOF). Use of inefficient open hearth furnaces (OHF) in China has been almost totally phased out.

There are considerable differences in the energy efficiency of primary steel production between countries and even between individual plants. The variation results from a number of factors, particularly technology, the level of waste energy recovery, plant size / economies of scale, the quality of iron ore,

[2] *Based upon production capacity of 660 mt in 2008 and production of 500 mt*

operational know-how, and quality control. Comparison of total sub-sector energy use per tonne of crude steel produced can be misleading because the production processes are very different.

Nevertheless useful indicators for this sector are:

- Total primary and final energy use per tonne of crude steel;
- Total primary and final energy use per tonne of finished steel produced;
- CO_2e emissions per tonne of crude steel.

2.3 Existing policy for energy efficiency and emissions in China's iron and steel sector

The Chinese Government has implemented a number of progressive policies aiming to improve energy efficiency and reduce emissions intensity. These include regulatory, financial and market-based mechanisms. The current Government five-year plan features a 20% reduction target in energy intensity, normalised against overall economic growth into energy consumption per unit of GDP. Implementation of this focuses on the largest 1000 energy-consuming enterprises through an energy saving target scheme. In the context of the UNFCCC negotiations, the Chinese Government has suggested a domestic 40 to 45% carbon emissions intensity reduction target by 2020 based upon a 2005 baseline. It is not yet clear how the target will restrict emissions from this sector. However, it is likely to be a major driver on measurement and reporting on this data, and mitigatory actions. Regardless of emissions policy, the financial crisis has affected steel demand and revenue for many companies. Subsequently, some planned projects have been cancelled or postponed. Despite this, China is the only country in the world building several brand new state-of-the-art integrated steel works which incorporate the latest designs and technologies (such as red-hot slab charging, combustion controls and HTAC) and feature fewer, larger blast and basic oxygen furnaces.

Top-down regulatory measures in China include forced closure of small and inefficient plants, mandatory upgrading to new furnace technology and reduction in over capacity. China is the engine of the world's CDM market and this has helped finance the implementation of many GHG emissions reductions projects (and improvements in emissions monitoring and verification practices) across a number of industries including iron and steel. Nevertheless, most sectors are still a long way from optimising energy systems by utilising the best available technology, minimising GHG emissions and installing extensive (and transparent) monitoring systems covering all inputs and emissions sources that would be necessary under a GHG inventory or cap and trade regime.

2.4 Reasons for high emissions intensity in China's iron and steel sector

Because the necessary disaggregated energy data for a representative sample of steelworks is not currently available for China to accurately calculate indicators of energy intensity, it is very difficult to estimate the energy or carbon intensity of steel produced in China or to compare this to production elsewhere. However, energy efficiency of China's steel industry is widely regarded to still fall short of international best practices. Table 1 shows a simple analysis of total Chinese crude steel output in 2007, equivalent energy consumption, and corresponding energy intensity compared to international best practice, for example. Poor energy efficiency translates directly to high GHG emissions intensity.

Table 1 Energy intensity of crude steel produced in China in 2007[3]

Output in 2007	Output (tonnes steel)	Energy consumption (GJ)	Energy intensity (GJ/t output)	International energy intensity (GJ/t)
Crude Steel	489 million	12,400 million	25.3	20.6[†]

Available information indicates that the Chinese steel sector as a whole is still not as energy efficient as other regions such as Japan, South Korea, Europe and North America due to a number of reasons including:

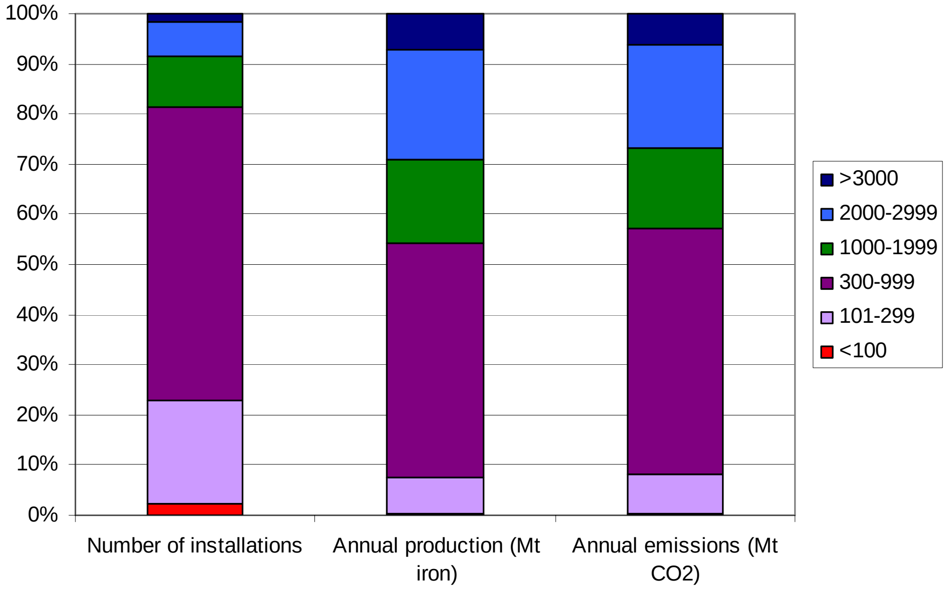
- Large proportion of small blast furnaces;
- High ratio of BOF for steel making;
- Limited or inefficient re-use of residual gases, heat and pressure; and
- Production overcapacity.

A regional trend is present as some technology has become common practice in more developed regions in the eastern coastal areas of China, but is still additional to less developed areas in western China.

2.4.1 Small blast furnaces

More than 80% of blast furnaces in China are smaller than 1000 m^3 capacity. The energy efficiency of blast furnaces increases with size, so the predominance of small blast furnaces leads to poor emissions intensity across the sector. Figure 1 depicts the breakdown of blast furnaces by size and how this influences emissions across the sector.

Figure 1 Breakdown of blast furnaces by capacity m^3 (China Iron and Steel Association, 2007)



The emissions intensity of each category of furnace is shown in Table 2. Based upon these figures, 18.5% of installations have blast furnaces with a capacity over 1000 m^3 and account for 43% of emissions. Of the 395 plants in total surveyed, 82% have capacities below this size and account for 57%

[3] *The energy intensity is calculated by dividing the energy consumption of smelting and pressing of ferrous metals for 2007 by the crude steel output for 2007 (NBS 2009).*
[†] *The comparison is only indicative because the international energy intensity comes from an alternative source (IEA 2008) and methodology is not defined.*

of all emissions. These smaller steel plants are less energy efficient and more carbon intensive. The Chinese government has set a target to close all furnaces below 300 m^3 by 2010, 400 m^3 by 2011 and 500 m^3 by 2012 (Chinese Government 2008). This will lead to corresponding improvements in efficiency, and so improved emissions intensity, across the sector. In China, several aging steelworks are being decommissioned and replaced by new integrated works with larger blast furnace and larger BOF capacities. Small to medium-sized companies are being consolidated and plants with aging equipment are being targeted by regional governments, forced with closure and relocation from populated areas to industrial zones. Chongqing Iron and Steel Group will soon complete the first phase of their new 10 mt capacity plant in located in the Changshuo Industrial Zone near Chongqing, for example. These types of domestic policies could be proposed as NAMAs under the Copenhagen Accord.

Table 2 China blast furnace production and emissions data by size in 2007 (China Iron and Steel Association, 2007)

Blast furnace capacity m^3	Number of installations	%	Annual production (Mt iron)	%	Annual emissions (Mt CO_2)	%	CO_2 intensity (tCO_2e/t iron)
<100	9	2.3%	0.95	0.4%	1.3	0.4%	1.37
101-299	82	20.8%	18	7.2%	23.9	7.6%	1.33
300-999	231	58.5%	117.6	46.7%	154.1	49.0%	1.31
1000-1999	39	9.9%	41.8	16.6%	50.6	16.1%	1.21
2000-2999	28	7.1%	55.5	22.1%	65	20.7%	1.17
>3000	6	1.5%	17.8	7.1%	19.4	6.2%	1.09
TOTAL	395		251.65		314.3		1.25

2.4.2 High ratio of basic oxygen furnaces

The BOF method of steel-making is less efficient than the electric arc furnace method. By 2006, approximately 31% of world steel plants had adopted the EAF process, with 67% using BOF and most of the remainder still operating very inefficient open hearth furnaces. In China, only 9% of plants utilise EAF, with the remaining 91% using BOF. Open hearth technology has already been phased out in China. Table 3 provides a comparison of the balance of EAF and BOF in leading steel-making nations in 2008.

Table 3 Global crude steel production in 2006 by process (WSA 2009)

	Production Million metric tons	BOF %	EAF %	OHF %	Other %
China	500.5	90.9	9.1	—	—
Japan	118.7	75.2	24.8	—	—
United States	91.4	41.9	58.1	—	—
Russia	68.5	55.2	28.4	—	—
India	55.2	40.0	58.2	1.8	—
South Korea	53.6	56.4	43.6	—	—
Germany	45.8	68.1	31.9	—	—
Ukraine	37.1	54.5	4.2	41.3	—
Brazil	33.7	74.8	23.5	—	1.6
World	1322.7	67.2	30.6	2.2	—

Although the most advanced steel works in China are better than the world average, the remaining majority of BOF steel plants reduce China's average energy efficiency and emissions intensity to below the world average.

2.4.3 Limited or inefficient use of residual gases, heat and pressure

Integrated iron and steel plants produce surplus combustible gas, heat and pressure at a number of points in the process. Gas is produced in blast furnaces, coke ovens and in BOF or converters within steel works. Heat is produced in sintering machines, coke drying and many other processes. Excess pressure is created at the top of blast furnaces. All of these energy sources can be harvested and used to raise steam, generate electricity or drive mechanical devices.

Until recently, besides some recycling of blast furnace gas, very little of this energy was recovered under normal practice in China. The availability of CDM finance has made many such projects viable over the past five years. There are however many further opportunities to reuse waste energy of this kind.

2.4.4 Production overcapacity

China's steel production capacity exceeds demand. For example, total capacity was estimated at 660 mt in 2008, yet production was just 500 mt giving a utilisation rate of 76%. The government is addressing this through the three-year moratorium on expansions and new plant construction, closure of smaller, less efficient blast furnaces and consolidation of small and mediums sized companies.

2.5 Energy saving and emissions reductions technologies in iron and steel sector

2.5.1 Available technologies

Some steel works in China have utilised several examples of the best available technologies to save energy and lower emissions, though many of these have been financed through the CDM.[4] Many technologies can be applied at different stages in the steel production process as shown in Figure 2. The most commonly employed technologies deployed by the large to medium sized enterprises are top pressure recovery turbine (TRT) to utilise excess pressure in blast furnaces, coke dry quenching (CDQ) to harvest surplus heat from coke production, and general waste heat recovery throughout the production process and utilisation of this heat to generate electricity. Waste gas produced as a by product, during the production of coke, sinter, iron or steel, can also be captured and utilised to generate electricity using combined cycle gas turbines (CCGT).[5] The adoption of inverters or variable speed drives (VSDs) to reduce electricity consumption by motors and compressors is also commonplace. High temperature air combustion (HTAC) technology, and pulverised coal injection (PCI) are also being utilised to improve combustion efficiency in the blast furnace. Automated combustion controls are also recommended to improve coke oven efficiency.

Installation of these technologies either involves retrofit or upgrade of existing equipment, or construction of new sub-process plants, or in some cases entirely new integrated steel works. Adoption of new clean technologies can be limited due to the increased cost of retrofit, including costs of production downtime. Uptake is also limited by the perceived operational risk of applying state-of-the-art technologies with insufficient references and successful case studies. Most of the top steel companies in China (which

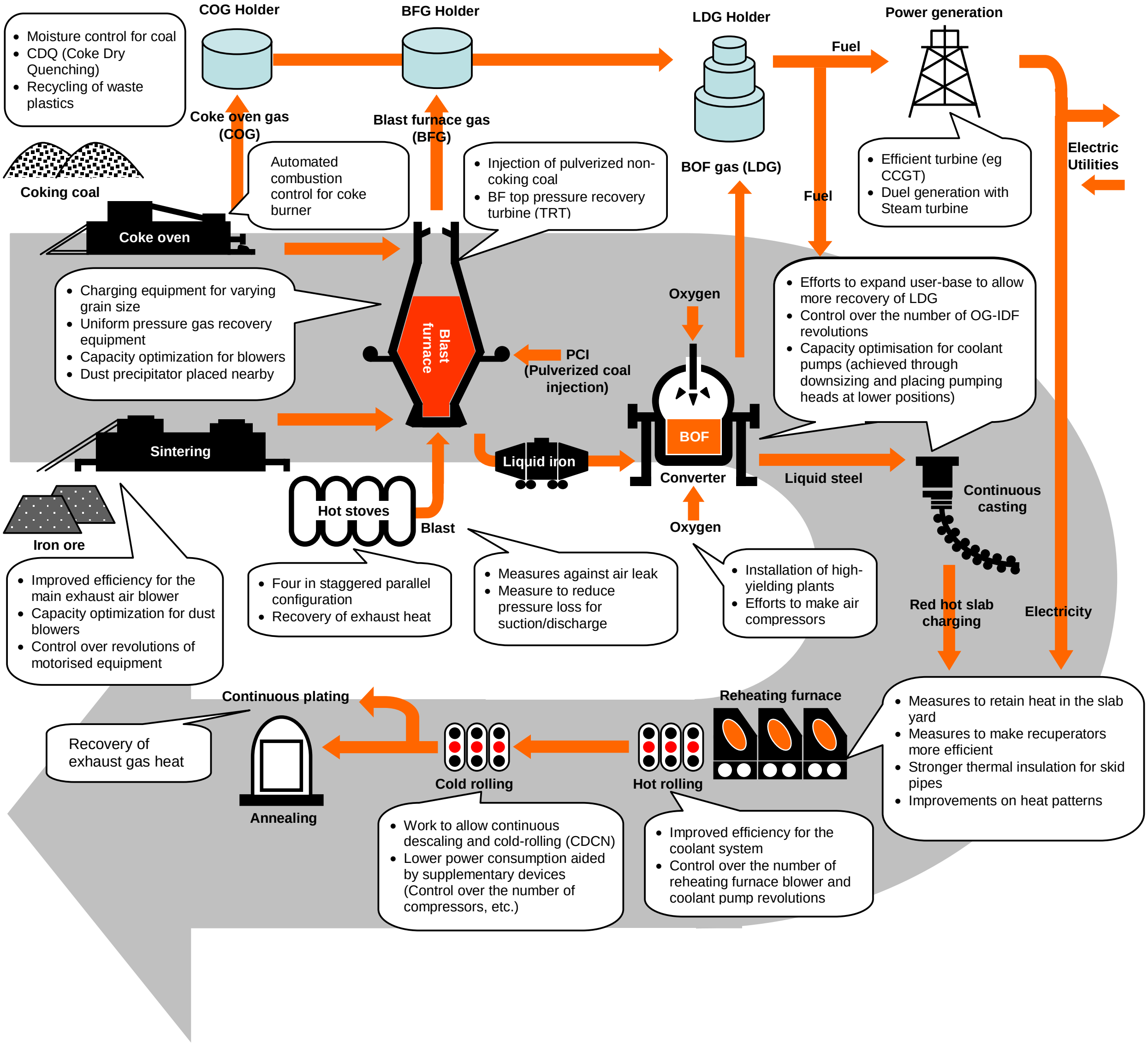
[4] The European Commission Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel (European Commission 2001) provides a comprehensive overview of these technologies. The Chinese Government has identified key technologies for the iron and steel sector in the National Key Energy Conservation Technologies Promotion Catalogue (the first batch) published by NDRC (NDRC 2008).

[5] Waste gas power generation using CCGT is referred to as Combine Cycle Power Plant (CCPP) in China.

includes three of the world's top ten producers) have retrofitted best practice technology to existing steel works, including CDQ, various applications of waste heat, gas and pressure utilisation, CCGTs, VSDs and PCI, often financed by the CDM.

These technologies differ in their potential to reduce GHG emissions as well as in capital and operating costs, and financial pay backs. The key technologies are described in the Glossary.

Figure 2 Best practice energy saving and emissions reductions technologies in steel production[6]



2.5.2 Technology performance

The performance of key technologies can be assessed on the basis of emissions reductions potential, costs and the return on the investment, as summarised in the Glossary.[7] TRT is one of the most widely applied technologies, utilising waste pressure at the top of blast furnaces, to save energy and reduce emissions. Equipment costs are upwards of RMB 20 million with potential emissions reductions around

[6] *This diagram is based upon examples of energy saving technologies in steelworks from the Nippon Steel Sustainability Report 2009 (Nippon Steel Corporation 2009) and additional measures have been added by Camco.*

[7] *A simple analysis of the projects registered under the CDM can indicate average performance. The typical annual emissions reductions, costs of investment and IRRs expected for the technologies are based on an analysis of 21 registered CDM projects in the iron and steel sector in China.*

0.1 million of CO_2e per year, and returns can be sufficient to achieve payback within two years. In contrast, recovery of waste gas and utilisation in a CCGT to produce power is one of the most expensive options for steel companies, with costs ranging from RMB 0.1 to 1 billion. These projects in China have a potential to save 0.15 to 2.5 million tonnes of CO_2e per year, but have a typical internal rate of return (IRR) of approximately 9%. CDQ systems installed in the coke production process also incur significant costs, with lower returns. Heat recovery and utilisation can save from 0.1 to 0.2 million tonnes of CO_2e per year but have poorer returns as low as 7%. Low cost measures can be retrofitted, with relative ease, are much cheaper and have short paybacks (e.g. inverters and VSDs cost from RMB 500,000 and can payback within 1-2 years). Carbon Capture and Storage (CCS) could play an important role in the future in reducing GHG emissions.

Table 4 Key energy saving and GHG emissions reductions technologies in the iron and steel section in China

Key technology	Potential energy saving or GHG reduction per installation	Typical cost (RMB per installation)	Average payback period
BOF/converter waste gas recovery	Up to 9.1 kWh/tonne of steel energy saving	About 100 million RMB	3 years
CDQ	0.1 to 0.2 million tonnes of CO_2e	400 million RMB	2-3 years
High temperature combustion technology (HTAC)	Up to 30% of energy consumed to generate heat in blast furnace	40 million RMB	1.5 years
Inverters or VSD for motor systems	10-30% energy savings in motor system	Medium voltage frequency converter for pump 600,000 RMB	1.5 years
Recycling of blast furnace gas and power generation	0.3 to 1 million tonnes of CO_2e depending on size of plant	10 million RMB	0.8 years
Sintering cogeneration technology	Energy saving per unit may reach 12kWh/tonne of sinter	170 million RMB	2.5 years
TRT	0.1 million of CO_2e per year	20 to 150 million RMB	2 years
Waste gas power generation (CCGT/CCPP)	0.1 to 2.5 million tonnes of CO_2e depending on size of plant	0.1 to 1 billion RMB	3-5 years

3 Existing financing mechanisms for energy efficiency and emissions reductions, and barriers and opportunities

- Most existing emissions reduction projects within iron and steel companies in China have been financed using a mixture of equity and commercial bank loans, backed up by the CDM.
- The CDM carbon market mechanism has made significant impact on the steel sector through incentivising projects that, otherwise, might not have been implemented.
- The most commonly employed technologies financed include TRT, CDQ, waste heat and gas recovery, utilisation and electricity generation, using CCGT.
- Chinese banks do not generally have the technical capacity to understand energy savings projects or emissions from iron and steel production, and lack the confidence and appraisal procedures for such investments.
- The Energy Performance Contract (EPC) and Energy Service Company (ESCO) mechanisms have not yet made a significant impact in bringing projects to fruition, due to a lack of awareness among steel companies of the services available and lack of technical capability amongst ESCOs. Steel projects tend to be too large and complex for this contract mechanism to work in practice.
- ESCOs still struggle to raise enough capital to finance large iron and steel energy solutions. Loan terms available to ESCOs are too short for projects with longer payback periods.
- Financial leasing is yet to make a big impact, due to lack of awareness among steel companies.

3.1 Overview

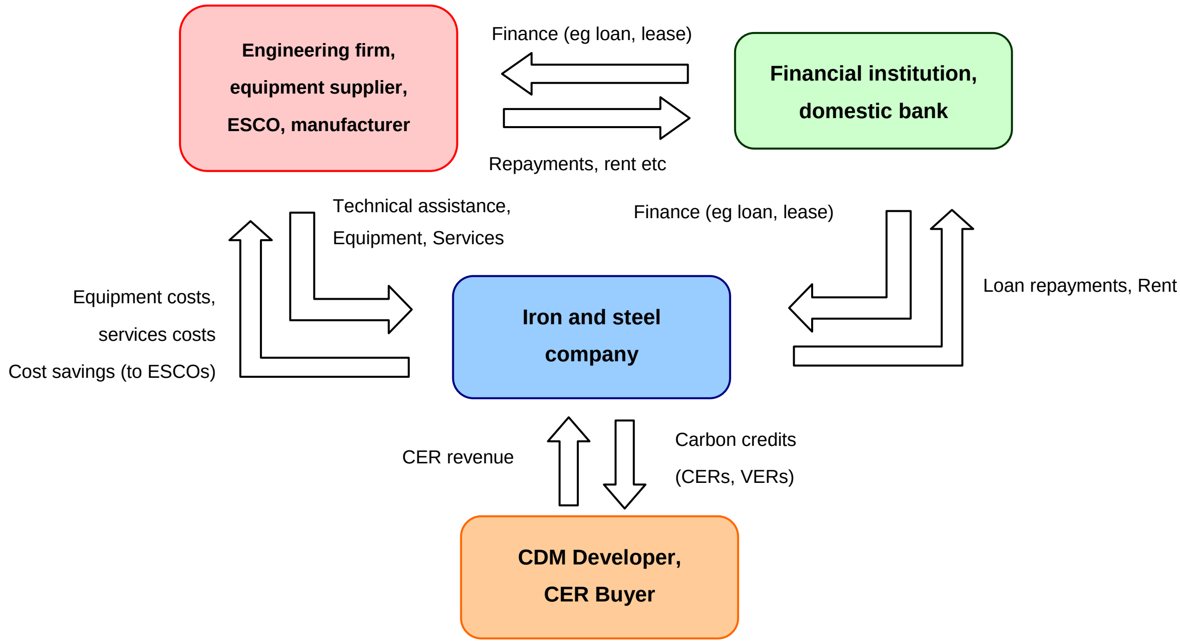
Currently in China there are several sources of finance for the retrofit, upgrade or replacement of equipment and the construction of new plants, which may result in greater energy efficiency (EE) and a reduction in emissions.

The key financing mechanisms are described in full in the Glossary. Iron and steel companies can obtain finance for projects through a number of channels, including debt (e.g. commercial bank loan), equity, or factoring. About half of energy efficiency projects in iron and steel field are self financed, while the most effective alternative mechanisms are commercial bank loans, usually backed up with CDM revenue. The average investment payback period for most technologies is around three years.

In summary, if the company can qualify for credit, then they may lease equipment directly from an equipment manufacturer, or indirectly from a leasing company. Alternatively, enterprises may agree a service contract with a third party to finance and implement the project, either using an ESCO under an EPC, or a build, operate and transfer (BOT) agreement. Certain projects may qualify for carbon credits, for example under the CDM or voluntary mechanism, so that once the project has been commissioned and emissions reductions are verified, the credits can be issued to the project owner, and sold on the appropriate market thus providing the additional source of finance and helping to convince banks to provide commercial loans. Companies can even sell the credits (normally at a reduction on the spot market value) ahead of issuance and project completion, and thereby generate capital for the project's implementation. In addition, tax incentives and rebates are available for specified energy efficient technologies.[8] The entities involved and relationships between them are shown in Figure 3.

[8] *The national Energy Saving Law (Chinese Government 2007), effective as of April 2008, stated that the manufacture and application of specified energy efficient technologies and products will be given preferential taxes. Seven technologies were relevant for the iron and steel sector, including TRT, CDQ, CCPP, blast furnace gas power generation, COG power generation, regenerative*

Figure 3 Entities involved in the financing of energy efficiency and emissions reductions projects



The current status and impact of each mechanism, limiting factors and opportunities to accelerate these mechanisms are described below.[9]

3.2 Commercial bank loans

Several commercial banks are not yet involved in the emissions reductions or energy saving equipment field in the iron and steel sector as there are several barriers preventing enterprises financing energy efficiency or emissions reductions projects with bank loans in China.

Barriers

- As might be expected, bank staff tend not to have suitable technical knowledge or understanding of industrial systems (especially complex steel production processes), energy saving investments equipment and performance monitoring procedures. Their ability to analyse risks associated with project performance is limited and so the perceived risks of these investments is high.
- Large iron and steel projects typically have payback periods of between three to five years. Traditionally, commercial banks are reluctant to loan over medium and longer terms.
- Access is made more difficult because of the type of investment. Energy saving or emissions reductions projects in iron and steel production require specialist equipment and engineers, and are considered to be high risk as they often do not perform as expected. These projects have been impacted further by a drop in expected steel demand, which reduces output and, in turn, reduces the energy saving/emissions reductions.
- Most banks do not have systems to support energy saving investments or the capacities necessary for application, appraisal and evaluation procedures for these types of investments.

combustion technology, and integrated energy management have been included in the national Key Energy Efficient Technology Catalogue issued by NDRC.

[9] *The current status and impact of these financing mechanism is based upon information gathered from a survey of eight Chinese financial institutions, three international financial institutions, seven Chinese iron and steel companies and 19 ESCOs undertaken by Camco and EMCA in China in August 2009.*

- The large state owned enterprises (SOE), which include most of the top steel producers, have either significant amounts of their own capital or wider access to credit, than compared to small to medium sized enterprises (SMEs) and private companies.
- Most companies engaging in energy efficiency projects are SMEs and commercial banks lack confidence in them due to insufficient credit history and a lack of collateral.

Box 1 Case study: China Utility-based Energy Efficiency Program

There are a number of initiatives which aim to overcome these barriers, build capacity and encourage Chinese banks to finance energy efficiency, renewable energy and emissions reductions projects. The International Finance Corporation's China Utility-based Energy Efficiency Program (CHUEE) has facilitated loans for several projects in China. For example, as of 31 March 2009, 99 Loans had been approved totalling USD 471 million for projects which together are estimated to reduce emissions of over 12 million tonnes CO_2e. This includes iron and steel projects (e.g. a RMB 13 million loan over a three year term has been provided to help finance a RMB 40 million TRT project in Sichuan).

CHUEE uses market partners (e.g. utilities, ESCOs, energy efficiency vendors and associations/government agencies) to provide specialist equipment and engineering services to customers, in cooperation with financial institution partners (including the Bank of Beijing, Shanghai Pudong Development Bank and Industrial Bank) who provide the loans to the customer. The IFC provide technical assistance to all partners and customers to build capacity and provide loss sharing facilities to financial partners.

The CHUEE mechanism helps raise awareness among and build capacity within domestic banks to deal in these types of projects and technologies. The programme helps develop the energy efficiency market, by enhancing loan availability and reducing collateral requirements. CHUEE also supports small, medium and private enterprises which may not otherwise have access to funds (e.g. around 67% of the borrowers quoted above are SMEs).

Addressing the barriers

- Continue to raise awareness and knowledge among staff of emissions reductions technologies and energy saving projects, the potential risks and mitigation actions, and financial returns. According to several domestic banks, the dissemination of information on all kinds including technology and energy-saving potential would be beneficial.
- Build capacities and systems among domestic banks to provide loans for these projects (e.g. application, evaluation, risk management and operation procedures).
- Build financial capacity among energy-saving equipment and service companies, to improve financial performance of contracts and projects.
- Introduce professional third parties specialised in EE projects (e.g. independent technical consultants, or ESCOs), to assist commercial banks to coordinate and support energy efficiency and emissions reductions project loans.
- Establish a longer term investment product suited to large energy saving investments.
- Banks could establish energy and carbon project departments specialising in these projects, and / or industrial and iron and steel sectors.

3.3 ESCO and EPC

The ESCO Committee of China Energy Conservation Association (EMCA) has over 220 ESCO members. There are over 300 ESCO companies operating in China. Based on a survey of its members, 505 energy performance contract (EPC) projects were implemented in 2008, providing a total investment of RMB 8.59 billion, and achieving an estimated annual energy savings of 5.84 million tonnes of coal equivalent (EMCA 2009). EPC and ESCO projects are financed using a number of channels. Some ESCO customers cover the cost of investments. Many ESCOs use either their own capital or apply for commercial bank loans. Most loan terms range from one to two years and the average loan amount ranges from RMB 40 to 50 million. Many small to medium-sized ESCOs would find it difficult to self-finance large iron and steel projects, and as a result ESCOs would prefer to work closely with commercial banks to conduct projects in partnership.

Barriers

- Most ESCOs are SMEs with limited available capital and insufficient banking credit record to qualify for commercial bank loans under current banking criteria, especially for the large-scale projects associated with iron and steel plant. ESCOs can struggle to raise enough capital to finance energy solutions.
- As with commercial debt, loan terms available are too short for iron and steel projects (3-5 year payback). Commercial banks are reluctant to provide long and medium term loans for energy efficiency projects. Most domestic banks can offer only a one year payback term.
- The EPC mechanism is still relatively new in China and most commercial banks do not understand the principle nor appreciate the financial benefit.
- Although there are a number of successful ESCO steel projects underway, many ESCOs believe that steel companies are not fully aware of the energy services available in China and that they are reluctant to outsource implementation to ESCOs due to lack of technical confidence or references.
- Current regulations and laws to support EPCs are deemed to be too weak by most ESCOs in the industry, causing problems when enforcing contracts to claim payments for achieved savings. Monitoring and verification of savings is also a contestable area, with many examples of disagreements.
- The majority of ESCOs applying for loans consider the amount of assets to be pledged as collateral required by banks to be too high. Small to medium ESCOs find it difficult to obtain guarantees.
- Several ESCOs believe technology to be a barrier which indicates that many ESCO do not understand the sector, are not aware of the best technology or lack the skills required.

Addressing the barriers

- Dissemination of information and promotion on the energy saving project / EPC mechanism for commercial banks, to address lack of understanding of available ESCO services, risks and mitigating measures.
- Development of regulations and laws supporting energy service contracts and strengthening of monitoring and verification procedures to ensure ESCO contracts are fulfilled by both sides and payments are received from energy savings.
- Commercial banks establishing mechanisms and systems tailored for ESCOs. Commercial banks could work closely with ESCOs to establish partnerships and engage in energy saving projects together.
- ESCOs suggest that the Government should take the lead in using EPC mechanisms, and through demonstration, stimulate market growth. The Government could also offer loss sharing facilities and underwrite a proportion of the risk of projects.

3.4 Financial leasing

Two approaches to leasing of energy-saving equipment are available to iron and steel companies: direct leasing or leaseback (or sale and leaseback). Direct leasing is particularly well suited for ESCOs who get income from the energy saved over the lifetime of the project. Payments or rent for the lease can be paid back in coordination with energy saving contracts. The leaseback option has particular benefits for equipment suppliers as capital is provided upfront. Leasing is yet to have a major impact on the iron and steel sector as relatively few emissions reductions projects have utilised leased equipment.

Barriers

- Currently, payback periods for iron and steel projects are still too high for many leasing terms available.
- Capital cost of equipment, such as CDQ or CCGT, is too high.
- Confidence in expected project performance and repayment are still low, meaning that perceived risk is high.

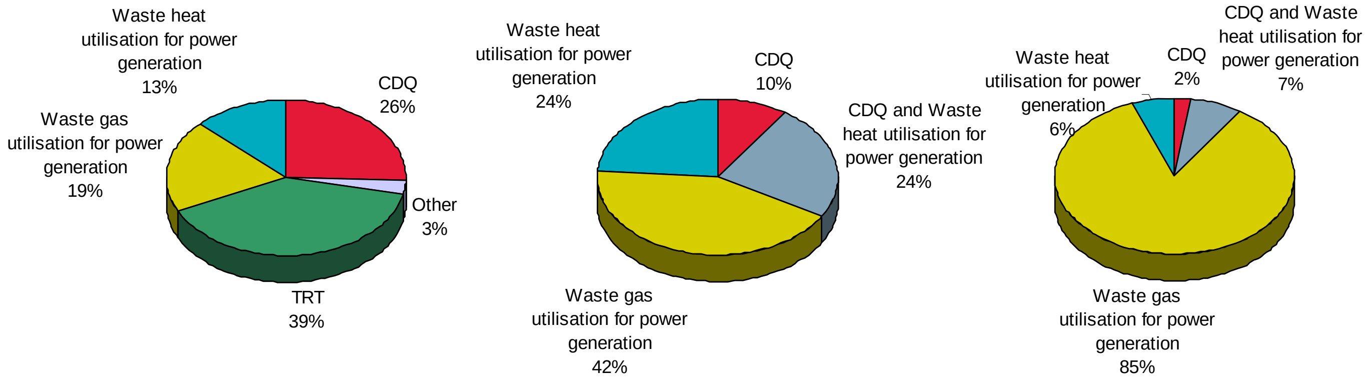
Addressing the barriers

- Improve the marketing of case studies and demonstrations to raise awareness amongst companies of equipment leasing, likely return and risks involved.
- Improved networking and communication between iron and steel companies, services and leasing companies.
- Capital costs and payback periods for equipment is high. Leasing can be used by ESCOs to finance EPCs and so overcome this challenge by linking repayments for the lease with energy and cost savings achieved by the projects.

3.5 Clean Development Mechanism

The CDM has made a significant impact on China's iron and steel sector through incentivising emissions reductions projects that, otherwise, might not have been implemented. As of 13 November 2009, the National Development and Reform Commission (NDRC) had approved 79 CDM project proposals in the iron and steel sector, 39% of which are TRT projects, 26% CDQ, 19% utilise waste gas to generate electricity (using CCGT), and 13% utilise recovered waste heat to generate power, as shown in Figure 4. Out of the 79 approved projects, so far only 21 projects have been registered by the EB, with a combined total investment of over RMB 13 billion and equivalent annual emissions reductions estimated at over 12.5 million tonnes CO_2e per year.

Figure 4 Percentage breakdown of iron and steel CDM projects organised by technology type: i) The 79 approved by NDRC ii) The 21 registered by the UNFCCC iii) Estimated annual emissions reductions of registered CDM projects



Recovery of waste gas using CCGT to produce power typically has a lower return than TRT, and projects utilising this technology have successfully registered under CDM. Out of the total 21 projects registered under CDM, nine are waste gas CCGT projects and these account for an estimated 85% of all emissions reductions by irons and steel CDM projects. Not all CDQ projects are eligible for the CDM because in some cases project financial returns can be higher than the required benchmark.

Barriers

- Additionality – as in the case of TRT, several technologies are not considered to deliver additional emissions reductions under current CDM rules and therefore do not qualify for CDM credits.
- Methodology bottlenecks – new CDM methodologies can take up to two years to develop. Development is also discouraged as authors of the methodologies do not benefit from being 'first mover' as other developers are free to utilise the methodology. Subsequently, new project technologies may be covered by existing methodologies in a suboptimal manner.
- Uncertainly surrounding post-2012 credits – uncertainly surrounding the future of the CDM beyond 2012 began to affect projects in the past two years as the post-2012 market for certified emissions reductions (CERs) is not clear, and demand and the price of credits reduced. Recent market transactions indicate that buyers are now starting to purchase post-2012 credits.
- Increased project development and validation costs – this is reducing projects returns and making it less attractive to attempt to originate projects with smaller emissions reductions.
- Increased time and effort to register projects – due to an increased number of projects in development and a lack of Designated Operational Entities (DOEs), the length of validation is increasing, slowing the overall delivery of emissions reductions.
- Smaller emissions reductions and methodology limitations – CDM has been effective in ensuring that large emissions reductions opportunities in developing countries (i.e. projects of 100,000 tonnes CO_2e per year or more) were implemented in fossil fuel intensive industry and power sectors. Subsequently, most of the biggest opportunities in the Chinese iron and steel sector have already been identified, leaving either small or less financially attractive energy efficiency projects. Alternative solutions require huge changes and amounts of capital and are not yet supported by current CDM methodologies e.g. Transformation from EAF to BF/BOF and CCS technology.

Addressing the barriers

- A revised, new or complementary mechanism could address these barriers and further incentivise GHG emission mitigation using a market mechanism to provide the additional finance in exchange for credits or offsets. It may be necessary to combine large-scale financing from climate-change funds with sale of project based offset credits to achieve increased scale of reductions.
- Sectoral emissions reductions mechanism (as explored in the Section 4) have, in part, been under discussion in order to address these barriers. Project-based CDM could provide the starting point for an evolution to new mechanisms with different methods for calculating baselines and additionality.
- In addition, programmatic CDM could help to provide credits for several small energy efficiency projects for an entire sector under a dedicated programme.

3.6 Bank factoring

This mechanism is less well developed in China and has only supported a handful of projects. For example, only the China Merchant Bank has supported energy efficiency investments in the iron and steel sector using factoring. The procedure is more complex in comparison to loans and the scope for disagreements regarding the monitoring and verification of energy savings and income seem to be high.

4 Sectoral approaches to incentivise emissions reductions

- The CDM in its current form would have limited effectiveness in achieving further emissions reductions in China's iron and steel sector.
- Sectoral approaches could involve crediting or trading based on absolute emissions, emissions intensity or technology penetration targets. The mechanisms could reduce emissions in the iron and steel sector further while providing opportunities for industry participants to increase efficiency and cost effectiveness.
- Domestic emission trading schemes under fixed binding caps are not yet practical for China's iron and steel industry, at least not until a pilot scheme has been successfully operated.
- Sectoral crediting mechanisms could benefit China's iron and steel sector by setting a "no-lose" emission intensity target generating additional financial incentives for companies who surpass targets. Sectoral crediting at a national government level could only provide incentives for individual plants to reduce emissions if domestic arrangements are implemented.
- CDM-style project crediting at a sector level, based on a sector no-lose emissions target, would not guarantee that national governments are able to meet the sectoral-level target and could result in significant government liability.
- Technology-based targets could help achieve higher penetration levels of best practice technology. Positive lists could also remove financial additionality barriers. However, there can be no guarantee these targets would correspond to actual emissions reductions.
- All approaches require a clear definition of the sector boundary and, for emissions intensity approaches, a definition of standardised product categories.

4.1 What are sectoral approaches?

CDM has two key limitations. Firstly it only operates as an offset mechanism, so it can not be used to provide incentive for emissions reductions to meet a host country domestic target, such as China's pledge to reduce emissions intensity by 40 to 45%. Secondly, it operates on a site-by-site project basis which means that the scale of reductions is anyway limited by the number of projects and the bureaucracy required. "Sectoral approaches" are sector-based market mechanisms or instruments which provide financial incentives for GHG emissions reductions across an entire sector, as opposed to an individual plant or project. They have been proposed as a means both to broaden the scope of GHG mitigation to include emissions reductions counting towards developing country targets, and to incentivise emissions reductions at greater scale across a sector within each country. The introduction of new, sector-based, market mechanisms is only one of many proposals discussed by UNFCCC Parties in the context of a post-2012 international climate policy framework, as a possible means to support mitigation actions in developing countries. It is likely that existing and new non-market emissions reduction policies, such as the mandatory closure of small blast-furnaces, would be incorporated into sectoral approaches. Commitment of a developing country to engage in such an approach may be one way for countries to demonstrate achievement of NAMAs as their contribution to GHG mitigation. However, determining which emissions reductions are attributable to the host country, and which can be sold to developed countries as offsets, is difficult.

4.2 Types of sectoral approaches

Current thinking divides sectoral approaches for GHG mitigation into two broad categories – (i) crediting, involving the award of credits for actual emissions reductions, and (ii) trading, involving the allocation of allowed levels of emissions (i.e. caps). Sectoral approaches can be further categorised into those dealing with emissions on an intensity basis (emissions normalised per quantity of product output), those dealing with absolute emissions and those based on penetration of specific technology types. The main potential options are summarised in Table 5.

Implementing such mechanisms raises a number of challenges, not least concerning the definition of a sector and the gathering of sufficient and reliable data. Certain proposed mechanisms have already been excluded from international discussions, for example the proposal to establish sector-level emissions performance benchmarks internationally and to compare performance between countries.

Table 5 Crediting methods against measurement techniques for emissions reductions

		Emissions intensity	Absolute emissions	Technology targets
Crediting (Awarding credits)	*National crediting*	Sectoral crediting	No-lose fixed national baseline	Technology crediting
	Project crediting	CDM with sector-wide baseline	Not applicable	Technology-specific CDM ("positive list")
Trading (Allocation of allowances or "caps")	*National allocation*	Possible under a no-lose baseline, but complex	Cap-and-trade scheme	Not applicable

4.2.1 Sectoral trading and crediting on an absolute emissions basis

If a fixed cap on absolute emissions can be established with strong confidence in underlying compliance, then a trading scheme would be appropriate. This is widely considered to be the most advanced type of sectoral approach whereby a binding mandatory cap is placed on a whole sector and emissions permits are allocated amongst installations. Many developed countries have already implemented or are in the process of planning such schemes. The EU ETS is essentially a similar approach covering a number of sectors all together. As a result, this approach is often promoted as a desirable future end-goal for sectoral approaches in developing countries, but it is generally accepted that this is too ambitious for most developing countries who will not accept legally binding targets. Domestic emissions trading ("cap and trade" scheme) is not yet practical for China's iron and steel industry. Significant lead time will be required to allow for sufficient demonstration and voluntary participation, development of baselines and targets (e.g. the UK operated the UK ETS for almost eight years before the EU ETS and binding targets became regulation).

Given that a binding cap is likely to be unacceptable, it is also conceivable that a crediting system could be operated using a target based on absolute emissions. This target would be have to be set for the whole sector and would take into account sector growth. As such it would be very difficult to set because of the uncertainty about industry growth and its effect on emissions levels. The target would need to be strict enough to avoid crediting actions that would have occurred in the absence of the scheme, but not strict enough to damage competitiveness and industry growth, because this would be unacceptable for the steel sector in China. The Government would then be issued credits if the sector as a whole could be shown to have total emissions below the target. As well as the target-setting difficulties, it would prove very difficult for the government to correctly distribute rewards to installations because each would vary in its growth and relative performance. Therefore this type of sector crediting is not considered to be a viable option.

4.2.2 Crediting under an emissions-intensity "no-lose" target

It is more likely that a sectoral mechanism based on emissions intensity will be acceptable in the Chinese steel sector. To measure reductions based on emissions-intensity requires calculation of emissions per unit of output, which in turn requires precise definition of the sector output, a complicated matter for integrated industries such as iron and steel production. Once the metric is established, crediting could be established either at a sector-wide level or a site level.

For all emissions-intensity metrics there are two different datasets to be measured and reported: the total emissions produced and the total quantity of production output. This doubles the challenge of ensuring reliability of data.

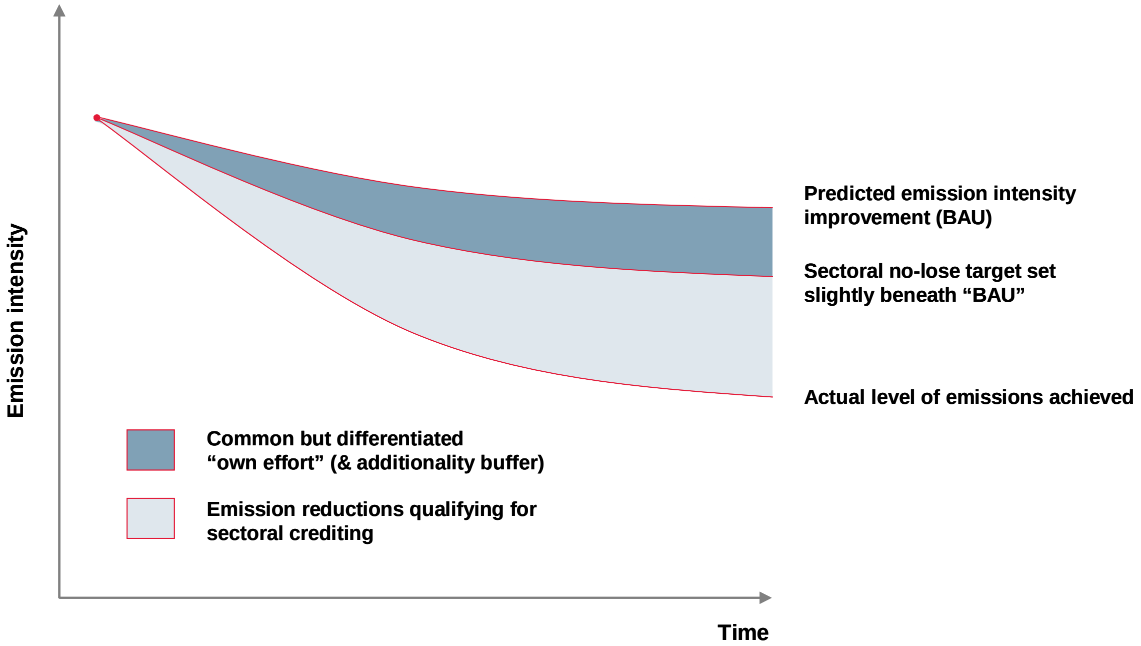
Figure 5 below depicts how an emissions-intensity target could be established in a sector on a "no-lose" basis. In this case there are three lines on the graph forming two shaded areas:

- The top line is the expected "business as usual" (BAU) level of emissions intensity that would naturally occur if no action was taken. For most sectors and most countries this line is likely to be downward sloping from left to right, i.e. efficiency improvements that have occurred historically will continue to be identified and implemented by the private sector in the absence of any additional policy or financial incentive. Determining the BAU level will depend on capacity for monitoring emissions across the sector and is also likely to be a matter of negotiation.
- The middle line is the sector no-lose target (SNLT) and is set at the level of emissions intensity that the government is willing to commit to without asking for carbon finance support. The gap between BAU and SNLT (once multiplied by the relevant volume metric) represents the emission reduction referred to as the developing country's "own contribution" and this will be calculated based on existing policy measures, such as the mandatory closing of blast furnaces, and other measures that the government is prepared to commit to without financing the reductions through offsets.
- The bottom line in the diagram is the actual level of emissions intensity achieved by the sector as a whole. The space between the SNLT line and the "achieved" line represents the actual level volume of international sector emissions reduction credits to be made available to the sector. The fact that the SNLT is below BAU means that there is an "additionality buffer" on international credits, ensuring that any further, deeper cuts in emissions intensity achieved are additional to that which would have occurred anyway.

The setting of the BAU and SNLT emissions intensity levels will be a subject of international negotiation between the host country government and the international community. Given that the SNLT is intensity-based, there is no guarantee of absolute emissions reductions. However, if annual emissions intensity improvement is above a certain threshold at an assumed sector growth rate, then absolute reductions would be expected. For example, assuming sector growth of 8% per annum, absolute emissions reductions would be achieved if emissions intensity improvement is greater than a threshold of 7.4% per annum.

It should be stressed that sectoral no-lose targets are no-lose - the key guiding principle has to be that countries and installations within countries which adopted such targets would not get penalised if they did not meet them. If countries choose to adopt binding domestic legislation to require entities to lower emissions under such a scheme – in order to achieve the SNLT – this is the host country prerogative and these would not be internationally enforceable; an example would be the forced closure of small blast furnaces.

Figure 5 BAU, Sectoral and actual emission reductions



Once an SNLT has been set, the government could implement the scheme through any of the schemes listed in the emissions intensity in Table 5: government sector crediting, project-level CDM-style crediting and, possibly, an intensity-based trading scheme operating under the SNLT.

a) Government sectoral crediting

A national sectoral crediting mechanism (sometimes known as SCM) would reward national governments for exceeding the SNLT. The sector as a whole will only receive credits if the government can demonstrate that emissions intensity on average is lower than the target, equivalent to the grey area in Figure 5. The volume of carbon credits delivered, in absolute tonnes of CO_2e, would be equal to the difference in emissions intensity below the baseline, multiplied by the total production of the sector for the year in question.

This approach would allow the government to easily implement national regulations, such as the closure of small blast furnaces, to help the sector come close to its agreed SNLT. However the key complication for this sector-wide approach is that the government would require a domestic mechanism for ensuring that the credits are delivered fairly to those installations that have contributed to improved sector performance. There would be no direct incentive for individual businesses to take action on emissions, unless they are confident that the government will reward their action. However, it is not obvious how to measure the relative performance of each installation in the sector. If all installations are compared to the sector average, some may be rewarded for no action, simply because they were already above-average plants, and this windfall would not be acceptable. The situation is further complicated if the sector as a whole does not exceed the target, perhaps because of a few large under-performing installations. In this case the government would not receive any international credits, but would need to reward well-performing installations if it sought to maintain confidence in the mechanism to obtain future credits.

b) Site-level project crediting

Site-level sectoral crediting is effectively project crediting and would deliver credits directly to individual installations. This could operate within a sector-wide SNLT if the government chooses to allow direct crediting to projects in order to maintain a direct incentive for individual installations. However, for this incentive to be effective, installations must be guaranteed rewards if they beat a clear target, regardless of how the rest of the sector performs. Installations will not invest if their reward depends on the performance of the rest of the sector. In addition to the problem of how to measure a sector-wide target across variable individual installations, this system could lead to the government accruing significant international liability for credits. If some installations exceed the target and receive international credits, but the sector as a whole under-performs, the government must be prepared to make up the shortfall of credits. In this way the system has lost some of its "no-lose" characteristic.

In effect, this would be a modified form of the CDM, the key difference being that the baseline would be set according to a sector-wide emissions intensity target. Once the target is defined across the sector, this would be taken as the baseline so allowing sites to develop projects if they can implement projects that will result in the emissions intensity for the installation becoming lower than the target. The incentive is therefore wholly in the hands of the individual plant management.

However, the development of a sector emissions intensity baseline and sectoral "no-lose" target line would be challenging. The baseline would require a representative historic sample or GHG emission inventory to ensure it is accurate. As production, raw materials and products are so varied, carbon intensity are likely to vary also, therefore some enterprises may find it much harder to meet targets. Variation effects are not an excuse because steel with a higher GHG emissions intensity should be discouraged.

c) Domestic trading of allowances under an SNLT

It could be possible for the host government to establish an intensity-based domestic emissions trading scheme beneath a sectoral no-lose target. In order go beyond its agreed sectoral target and be eligible for sectoral crediting, the government could establish a domestic trading scheme with a target below the SNLT. The further below the line, the more the government would secure in carbon revenue.

At the beginning of each year, installations are allocated a number of allowances calculated through multiplying the target emissions intensity by the expected volume of output (however defined). At year-end, an additional allocation or "clawback" is made, dependent on the actual level of output. Installations are then required to surrender allowances to account for their actual emissions.

During the year, a business can monitor its emissions intensity performance and its production levels. If installations emit more than their allocation (after the year end volume adjustment) then they can buy allowances from the market. Similarly, an installation that emits less than its allocation can sell its surplus allowances. In this way, a scheme could be designed that sets an ongoing carbon price with allowances traded as if under an absolute scheme. The "additional allocation" or clawback (where less production occurs than expected) would introduce a degree of volatility in to the scheme at year end, but with banking allowed, and ongoing volume monitoring by companies, this could be improved.

This approach, although theoretically efficient, is likely to be difficult and complicated to implement in practice because of unfamiliarity with trading schemes and the complex conversion between intensity and absolute emissions in such a scheme.

4.2.3 Technology targets

Recently some countries, including China, have proposed technology-based sectoral approaches, concerning the penetration of a particular low-carbon technology within a sector. Countries could accept targets for achieving emissions reductions associated with a certain level of penetration of technology. This could be easier to implement than the other approaches because of the lack of site-by-site monitoring, reporting and verification, but it would be a significant challenge to ensure that technology performs as intended and reduces emissions as anticipated.

a) National crediting

One way that technology targets could be applied is at the national level across a sector. A country would set a target level for roll-out of technology – for example committing to ensuring that 80% of iron and steel plants implement CDQ. Past data could be used to calculate, on average, how well CDQ performs in terms of emissions reductions, so the corresponding emissions reductions target could be quoted in tonnes of CO_2e as per other targets. This target could then be a fixed target with penalties for failure, or a voluntary target, or a no-lose target with carbon credits available for a sector that moves beyond the target for technology penetration. Note that whilst the target would probably be set as a percentage of some kind (% technology introduced, or % output from improved processes etc), the credits available would still be in tonnes of CO_2e reduced.

b) Technology-specific crediting

A simpler means of using technology targets would be to continue crediting installations through a system of technology-based projects. In this case, technology lists would be defined for being eligible and individual sites could develop projects using approved technology types without having to go through laborious proof to show that emissions reductions are additional. Emissions would still be monitored and verified on a site by site basis and emissions reductions could be calculated *ex-post* against a business-as-usual baseline. However, this is not really a sectoral approach. It is difficult to see how such a system could be linked to a sector-wide target to reduce emissions because it could not function under a penetration target; installations would not take the risk of investing only to find that, because the penetration target has been exceeded, they cannot receive credits. The only way to control the supply of credits would be through restrictions in the list of available technologies, so it would be difficult to use this system to pave a way towards a sector taking an overall binding cap.

Table 6 Advantages and disadvantages of alternative sectoral approaches in China

Parameter	Desired outcome	Ex post sectoral crediting mechanism	Sectoral CDM at a site level	Sectoral technology targets
Emissions reductions	Achieves stable, repeatable reductions in either absolute emissions or emissions intensity, relative to a precise baseline	× No-lose and intensity nature of target means that absolute savings from the sector cannot be guaranteed	× No guarantee of total emissions reductions for the sector, rewards good performance but ignores bad. More so than for SCM, no guarantee that emissions intensity for whole sector would reduce (let alone absolute emissions) and Government would not fine bad participants	× Decoupling the target from real, monitored emissions reductions could result in lack of credibility of emissions reductions and dilution of international markets linked to the scheme
Measurement, Reporting and Verification (MRV)	Allows easy to implement and cost effective means to measure and report on emissions reductions	× Relies on data from across the whole sector to function reliably	✓ × MRV is site-level and so no different to existing CDM requirements. But baseline requires high-quality data from across the sector which may not necessarily be available	× Targets are clearly visible and comprehensible, but aggregating technology roll-out across sector is difficult and linking these data to reliable emissions reductions is difficult to achieve
Incentives	Provides sufficient incentive to ensure that required actions are attractive to private sector entities, without leading to windfalls or supernormal profits	× Does not provide any direct incentive to the private sector; must rely on Government to distribute benefits. Good performers could be penalised by bad performers that drag down the sector average	✓ Incentives delivered directly to the private sector, success of CDM in motivating private businesses to take action on emissions is continued without government interference.	✓ Although credited on a national level, private sector entities may have better visibility of how the incentive links to individual actions (when compared to other national sectoral crediting methods)
Competitiveness	Maintains competitiveness and does not distort the market to the extent that entities are affected	✓ Lack of binding cap on absolute emissions means that competitiveness is not a big concern for entities affected by the mechanism	✓ Lack of binding cap on absolute emissions means that competitiveness is not a big concern for entities affected by the mechanism	× The technology specific target could impinge on competitiveness relative to the same sector in other countries, depending on the level of the target
Political acceptability	Sets a level of challenge beyond the selected baseline that is acceptable to host country governments and to the international community	✓ Can be politically acceptable because the target is "no-lose" and so carries no downside, and because the level of target is negotiable depending on level of financing for NAMAs and other policies	✓ Likely to be politically acceptable amongst developing countries, and particularly supported by the private sector	✓ Politically acceptable to Governments because of the emphasis on technology improvement
Technology transfer	Encourages technology transfer to developing countries in a way that does not infringe concerns over intellectual property rights	✓ × Technology transfer may be encouraged across the sector, but only if confidence in the incentive is maintained	✓ Site-level guarantee of crediting for installations exceeding the target means this model is quite likely to be effective at providing technology transfer	✓ × The technology specific target should provide strong encouragement for technology transfer, at least for the specific technology types specified However, may raise issues about intellectual property rights for transfer of technologies from other countries
Investment flows	Provides a stable framework over a long enough timeframe to release investment within the sector and attract significant investment from outside the sector	× Uncertain incentives and need to rely on performance of the rest of the sector means that investment may not be forthcoming	✓ CDM is continued with many of the uncertainties over additionality standards removed for the sectors concerned, and this provides some certainty for project investment.	✓ Visible nature of target should encourage release of investment within the sector
Stepping stone to national reductions	Acts as an effective stepping stone towards future economy-wide emissions targets and/or global carbon price	✓ Can provide a good route from having all actions credited (as with CDM) to certain actions being credited and other lower-cost abatement actions being undertaken without support from int'l carbon markets.	× Does not pave the way to moving beyond offset provision to developing countries contributing to mitigation through binding targets	× The lack of any direct emissions target means this would not act as a good stepping stone towards sector or economy wide caps. Relating individual sectors to technologies would depend heavily on how the sector is defined

4.3 Applying sectoral approaches in China's iron and steel sector

China's iron and steel sector could benefit from sectoral mechanisms, through increased access to new technologies and finance in the form of credits for improving emissions intensity compared to a national sectoral benchmark. However, the sector participants must ensure that the scheme chosen by the government is practical and appropriate to China's iron and steel companies.

The challenges for the iron and steel sector now are:

- To understand and interpret the implications of international negotiations on climate change;
- To determine the practicalities of applying sectoral approaches, and how they can benefit the sector, while enhancing the sector's contribution to emissions reductions.

4.3.1 Definition of the sector

Integrated iron and steel plants form a complex supply chain with many inputs, outputs and internal transfers of materials, gases and energy. To define a single sector that is consistent both within and between plants that is meaningful in emissions terms is difficult. Issues to consider are as follows:

a) Up to 80% of emissions released in steel making are from iron ore reduction in the blast furnace. However, the combustible gas that is produced in this process is usually collected to some degree and is reused either in the blast furnace or elsewhere in the plant, so the final venting of CO_2 to atmosphere occurs at a different part of the plant.

b) Different iron and steel plants have differing levels of self-sufficiency. Some plants buy coke and pellets from outside whereas others produce all coke on site; the latter will have greater emissions within the plant boundary but will not necessarily be themselves more efficient. The plant that has purchased coke has just "outsourced" their emissions to a supplier. If a sectoral mechanism is imposed on the iron and steel plant but not the supplier, the situation is neither fair nor optimal.

c) Plants use different quantities of scrap steel to feed into the steel making process. This can vary both between plants and within a single plant over time. More scrap means lower on-site emissions. Although this situation would create an incentive to increase scrap recycling, with corresponding environmental benefits, it may not form a balanced and effective emissions policy.

d) Plants produce different products. Some plants generate electricity that is either sold "over the fence" or consumed onsite to reduce dependence on grid-generated power. If this power was excluded from the sector definition then the incentive to capture waste gas for power generation would be removed. Similarly, the sale of the waste gas itself to neighbouring plants, as well as the sale of emissions-intensive products such as excess coke produced on-site, would all need to be counted within the sector if strong incentives are to be maintained.

One possible solution to this sector definition problem would be to restrict the definition to include only blast furnace operations, covering 80% of emissions. This would eliminate many of the boundary issues identified above and the product could be defined as liquid iron. However, all incentives for efficiency in the upstream (e.g. coke and sintering) and downstream (e.g. steel making, milling and rolling) process would be lost.

4.3.2 Definition of product

For wider sector definition, issues of comparability arise. The product could be crude steel, rolled steel or finished steel and would vary between plants with different downstream processes producing different product classes. GHG emissions per unit of GDP or per tonnes of crude steel produced would encompass most emissions targeting the most energy intensive steps of steel production (e.g. from sinter to steel making). However, measures will have to be put into place to prevent leakage, e.g. a company could outsource coke, sinter and iron making to reduce the carbon intensity of their products. A single sub-process cannot be singled out due to the integrated recycle/reuse nature of steel production (e.g. by product gases such as coke oven gas can be captured and used as a fuel in the steel making, meaning that the emission takes place at a different location in the chain).

4.3.3 Reliability of available data

Most of the approaches described rely on good data availability across the sector. This can be problematic on two fronts: the data may not be physically available in sufficient detail in many plants and, even if it is, it may not be easily accessible for reasons of commercial sensitivity. This needs further research with industry participants to address issues such as: how much data would be available and would this cover enough of the sector to ensure that a sectoral system can function correctly, and how much of this data could be published and shared around the industry as a necessary precursor to calculating benchmarks and sectoral targets.

4.4 Appraisal of sectoral approaches with industry

For the purposes of this study, a consultation has been undertaken to determine which sectoral approach is most appropriate for China, what problems China might encounter when introducing the potential mechanisms, which approach is likely to encourage greater mitigation, and how the sector can benefit. The consultation targeted key stakeholders including major iron and steel companies in Chinese, the China Iron and Steel Association (CISA), independent steel experts, academics and non-governmental organisations (NGOs), all with experience in relevant fields.[10] The following sections summarise the key results from the consultation. Technology advancement is core to the development of the Chinese steel sector, and new mechanisms that incentivise greater deployment of best practice technology are preferred by stakeholders.

Most steel industry stakeholders consulted agree the CDM is beneficial, however they also state it is too complex and should be reformed and simplified, rather than introduce some new sector based approach. Most steel companies found the various sectoral mechanism proposed to be too complex. Most Chinese climate change experts consulted relate the term “sectoral approaches” to “sector-wide caps” and therefore have strong unsupportive views on this matter. The technology approach has greater support among Chinese stakeholders due to its simple and practical design and apparent link with technology transfer.

4.4.1 Clean Development Mechanism

For the existing CDM, the majority of interviewees think it is a good approach for carbon mitigation, with a minority expressing a clear negative attitude.

The majority iron and steel companies surveyed take the CDM as the best existing mechanism for stimulating emissions reductions in China. The CDM is reasonable and practical and should be supported before other new approaches are developed. This mechanism is well regarded to contribute to the implementation of energy efficient projects and reduction in GHG emissions of the Chinese sector through providing international financial support, and promotes the application of advanced global technologies.

A minority of companies objected to the CDM mechanism for several reasons. Some questioned whether the CDM was the main driver behind the deployments of new technology, as they consider that some

[10] The consultation, and associated workshops, were undertaken by Camco and ERI in China between August and October 2009 and involved seven Chinese steel companies, the CISA, six independent steel experts and academics, and other contributors.

projects may have gone ahead with or without CDM financing. Conversely, in some projects the CER revenue may not cover additional operation and maintenance costs of new technology, such as combined cycle gas turbines. Recent drops in carbon prices have reduced expected CER revenues, which in turn has increased the costs of certain abatement projects. If low carbon prices continue in the future, abatement costs could remain too high for CDM projects to go ahead. Finally, CDM has not provided sufficient help in terms of technology transfer as expected.

Industry representatives and experts agree that existing CDM needs to be improved, including making methodologies less complicated and inflexible, shortening registration time and educating third parties about iron and steel industries and technologies.

For the future of CDM, the supporters of it think it should continue in order to fully take its effect on carbon mitigation, though it needs reform and optimisation. Reform options could include the following:

- The CDM process should be streamlined to reduce complexity and establish more effective certification processes.
- Coverage of CDM could be expanded to include more energy-efficient and innovative technologies including demand-side-management (DSM) technologies and small-scale technologies with smaller mitigation effects, etc.
- CDM could be integrated with other approaches, including using voluntary approaches and actions to supplement CDM, so that in time the CDM could be replaced by new approaches (e.g. sectoral approaches) to drive further mitigation actions.

The feedback indicates that several companies are only just coming to terms with the CDM and understand the financial benefits. Subsequently there is resistance to propose new mechanisms to replace the CDM. Several companies object to the complicated validation and verification processes preventing payments (e.g. only six out of the 21 registered CDM projects have actually issued credits). Instead they would prefer simplification to accelerate validation and verification. On the other hand, those iron and steel companies which have benefited from CER revenue appreciate the barriers preventing further projects, and may also have a competitive advantage over other companies.

4.4.2 Most appropriate sectoral approach for China

The majority of interviewees prefer the technology-based sectoral approach because they see it as more straightforward and more applicable and implementable for China. Boundary definition is easier for this approach. For environmental effectiveness, although it may exclude some emissions reductions potential, it could nevertheless cover key sources of carbon emissions and at the current time could be a good approach to keep track of funding, technology improvement and carbon mitigation comprehensively. Interviewees think that some of the problems identified for this type of approach can be resolved through good design. For example, the technology list could be upgraded regularly to include most innovative technologies based on experience from project implementation. It would be essential to monitor and assess the impacts of this approach, and when calculating carbon reduction resulting from the approach, the method of minimum emissions reductions can be used to make the projects comparable. However, the need to be conservative about emissions reductions could lead to very small volumes of credits and corresponding financial shortfalls.

Certain experts in China also support the intensity-based approach in that this approach is relatively impartial and relatively easily to apply. Experts pointed out that it is important to set up appropriate models to properly calculate the energy intensity. In addition, regarding the problems that incentives might not be distributed evenly in the sector, some experts argue that it can solved if a flexible mechanism can be adopted to re-allocate government credits across the sector, to ensure that active enterprises can acquire the proportional awards.

Most interviewees oppose approaches with absolute emissions caps. Moreover, some experts think the selection of these different approaches should depend on different situations. Industry interviewees suggested that different approaches could be applied to different types of enterprises, to distinguish between old and new enterprises. For new enterprise, the technology-based approach could be used and linked with national incentive policies for advanced technologies and facilities. However, replacement of entire steel making furnaces is a major investment for plants and, aside from legislation or stipulated technology targets, it is not clear whether a sectoral approach based on carbon credits would deliver sufficient incentive to make this transition.

For implementation, interviewees suggested that the adoption of approaches should be phased. In the short term, importance is given to the development and definition of a carbon accounting format and methodology for enterprises, including international standards for monitoring, reporting and verification, based on which the appropriate approach can be adopted in the long term.

The feedback indicates that the technology penetration approach is preferred by industry participants. Absolute emissions targets are seen as unacceptable and too restrictive for growth, and intensity-based sectoral crediting is seen as too complex and too far removed from CDM. Industry participants would prefer to see phased gradual implementation of sectoral approaches so that sufficient greenhouse gas accounting and monitoring capability can be developed.

4.4.3 Definition of the sector

The majority of interviewees preferred to define the sector to include only part of the production chain, such as those before the iron product, but not the whole production chain.

The majority of interviewees think that in practical operation, defining the sector to include only part of the production chain has some advantages, including that: i) it catches the main emission source and also resolves the remaining problem of how to define the product unit; ii) it can ensure equity and comparability, facilitating plant comparison; and iii) it can work for both long-chain process and short-chain process, and the different processes in iron and steel production such as coking, sintering, iron making and steel rolling should be separated to define the corresponding index individually.

On the other hand, some other experts support the defining of the sector to include the whole production chain because they think that: i) from the global point of view, some international organisations or initiatives such as WSA and GHG protocol initiative define the sector boundary clearly, including the whole process chain of steel production; and ii) including the whole production chain can ensure maximum mitigation effect, and if the process upstream of iron production is excluded, many mitigation options such as energy saving technologies and management might not grow.

The feedback indicates that industry participants are split over how they would prefer to define the iron and steel sector. Although the majority of industry representatives would prefer to define different parts of the steel production process as independent sectors, experts see the value in defining a holistic sector that allows application of international standards and comparisons.

4.4.4 Definition of the output used to calculate emissions intensity

Almost all industry representatives and experts agree with using crude steel to define the output, because: i) it is comprehensive and at the same time avoids the complexity of using finished steel as the definition of output; ii) it is consistent with current national statistics and standards; and iii) it might depend on the defining of sector boundary discussed above because if the sector is defined to include only some part of production chain it is not necessary to define the product output.

It is also recommended by some interviewees to use carbon emission per economic added value, similar to the national energy intensity index, to calculate the emission intensity. In this case, a combination of these different intensity indices may also be applied to acquire a higher comparability.

> The feedback indicates that the emissions intensity is preferred over absolute emissions metric. Furthermore, feedback shows that the normalising metric used to calculate emissions intensity should be tonnes of crude steel produced.

4.4.5 Data availability and data management

Most interviewees think that steel production data is relatively complete and is of good quality and reliability, since most iron and steel enterprises pay more attention and have more control of data relating to material use and product output than they do emissions data. As a result, almost all enterprises (probably as high as 99%) could provide reliable output data if they are not reluctant to do so. However, energy consumption data have high uncertainty, and only about 20 to 40% of steel enterprises might provide reliable data. By comparison, the key large-scale enterprises have an advantage in the monitoring of energy use and correspondingly good data dependability, so small enterprises would need significant assistance in this regard.

With regard to data availability, enterprises are very cautious about providing data because they are concerned about competitiveness and therefore keep the data confidential. Therefore, without sector regulation and mandatory disclosure forced by government, the enterprises will always provide approximations and this will lead to errors. In addition, for energy consumption data, the ability of enterprises in monitoring and calculating the energy consumption needs to be improved, particularly for small enterprises.

The following data are very difficult to acquire currently: i) energy consumption by fuel type and by production process; ii) the corresponding carbon emission factor; iii) pressure and thermal efficiency data in each process; and iv) the amount of scrap steel.

> A robust and transparent sector-wide monitoring, reporting and verification scheme is fundamental to any future international mechanism (or domestic emissions intensity policy). The CDM has helped build capacity in this area in the iron and steel sector. Most companies (i.e. the large ones) consulted have the necessary metering equipment and management systems necessary to gather energy consumption data necessary to calculate emissions (which most large companies have to report already on a monthly basis to the National Bureau of Statistics under the 20% energy intensity target together with production). However, smaller enterprises may need capacity development in this area.

4.4.6 Technology list

There are many technologies in iron and steel sector that should be further encouraged, as shown in the project list promoted by the national energy-saving industry policy. Currently, most best-available technologies for iron and steel production globally have already been used in China, albeit with CDM or other support. In the short term, key technologies qualified to be encouraged should include the following, also described in the glossary:

- CDQ, TRT and CCGT (utilising combustible blast furnace gas, coke oven gas, and BOF/converter gas).
- Other technologies for recovering waste heat and pressure.

- Technologies to improve the collection and reuse of scrap steel.
- Technologies to reduce electricity consumption, such as VSD.

In the long term, the key technologies qualified to be encouraged should include:

- Melting reduction technologies (including COREX, FINES technologies).
- Opportunities for CCS technology, particularly for blast furnace emissions.

Other possible technologies include: installing dedicated production and energy management centres, CMC technology, new-generation coking technologies (such as SCOP21), the Itmk3 (*Iron Technology Mark III*) process and Castrip technology.

5 Recommendations

China's steel sector has made some major advances in improving efficiency and implementing emission reduction projects in the last ten years. The CDM has been an effective financing mechanism. As global steel demand is forecasted to increase in the medium to longer term so will GHG emissions from the Chinese steel sector. Enhanced financing mechanisms, more efficient and innovative technologies, such as utilisation of CCS, and further emission reductions are therefore required to accelerate and widen GHG mitigation.

5.1 Recommendations for further studies

Identify and appraise nationally appropriate mitigation actions and financing. There are many technologies, national measures and financing mechanisms which reduce emissions in the Chinese steel sector and could reduce carbon intensity. The Copenhagen Accord states that Non-Annex I Parties will implement climate change mitigation actions to be proposed and developed in 2010 (including relevant technology, finance and necessary capacity building support). NAMAs can be financed with domestic or international funds. As yet, it is not clear what measures (e.g. sector wide deployment of CDQ, greater application of EAF and recycling, BF combustion controls) are most appropriate for the steel sector. There is no basis for determining how international finance can be divided towards these measures, other than the CDM. The Chinese steel industry could be consulted on this process to identify the most practical options and additional capacity required to aide implementation. How sector-wide mitigation actions could contribute the national 40 to 45% target could also be examined.

Develop emissions assessment and monitoring guidelines and GHG emissions inventory. Internationally-financed measures may be subject to international guidelines or standards. Robust GHG emissions accounting procedures, which meet international expectations (e.g. ISO 14064), could be developed amongst stakeholder groups and industry participants, including clear definitions of the sector boundary and steel product. The feasibility of extending the sector beyond the blast furnace could be discussed, for example. The procedure could also be piloted with selected companies or on a voluntary basis using a periodic reporting mechanism to collect data and account for GHG emissions. A designated coordinating entity could collect and track emissions data. UK and EU ETS experience could help build capacity for accounting and supervision at company and local government level. Chinese standards making bodies, such as the China Institute for Standardization (CNIS) could assist Chinese standard development.

Energy efficiency levels and abatement costs. It is widely accepted that the level of technology development, deployment and efficiency varies across the Chinese iron and steel sector. Research could identify output, consumption, energy efficiency, technology penetration percentage levels for the sector, and determine to financial cost to upgrade, rebuild and improve the efficiency and emissions to required levels. This could help establish a baseline.

Investigate how sector targets and existing financial mechanisms, such as the CDM, could interact with the 40 to 45% national emissions intensity target and develop baseline scenarios (based upon a GHG inventory and existing policies) and a sector no-lose target.

Raise awareness amongst the steel sector in China on drivers for the assessment of steel carbon intensity, communication and public disclosure. These include international competition, China's 40 to 45% national carbon intensity target, the threat on border tariff adjustments and the increase in demand for GHG emission/carbon labelling by foreign customers.

5.2 Recommendations for policy makers

The policy-focussed recommendations are arranged into four categories: mechanisms and incentives, matters relating to project finance, the need to raise awareness and to improve services.

5.2.1 Mechanisms and incentives

Pilot carbon trading. Develop the national market, systems and experience within the iron and steel sector in China, including the trial of a domestic GHG emissions trading scheme which could operate under a SNLT (e.g. steel sector and cross-sectors pilots with incentives and penalties). Chinese companies could be invited to participate on a voluntary basis and it would involve domestic financial institutions and environmental exchanges in capacity building exercises. Utilise international experience from setting up the EU ETS (e.g. UK Government and experts developed its own pilot scheme and helped establish EU scheme).

Emission intensity targets and incentives for the steel sector. It is not yet clear what the 40 to 45% carbon intensity target will mean for steel companies. Steel sector targets and incentives and incentives set up for enterprises could be proposed in accordance with the approaches outlined in this report. A voluntary SNLT could be tested, for example. Companies who surpass the SNLT could be eligible for an incentive funded through international sector-based offset mechanisms. Compliance with existing polices ahead of deadlines (e.g. closure of small BF in 2010 ahead of the 2012 deadline) could be counted towards target achievements. The amount of reductions which qualify for crediting under the international sectoral crediting mechanisms could be equivalent to the how far the company surpasses the target. Non compliance with the sector emission intensity target would not be penalised.

Governments could prioritise reform and streamlining of the CDM to reduce complicated procedures and accelerate investment in emissions reductions. The CDM is likely to continue beyond 2012 for various sectors and countries. Existing mechanisms, domestic policy, new approaches and pilot schemes will have to coexist and complement each other. The CDM has a part to play in achieving further emissions reductions across the steel sector and serving as a model for evolution of sectoral mechanisms.

5.2.2 Finance

Improve access to long term commercial loans for steel companies and ESCOs to finance emissions reductions and energy saving projects (especially for SMEs), e.g. expand programmes such as the CHUEE. Efforts should increase access to domestic finance, diversify sources and direct market development.

5.2.3 Awareness

Encourage the iron and steel association and other related organisations to play more important roles, help raise awareness on topics such as carbon targets, NAMAs and MRV (e.g. leading discussion and development groups for GHG reporting and MRV) and suggest how technology targets could be implemented in practice.

Consider financing demonstration projects to pilot selected state-of-the-art low carbon steel production technologies which are not yet commercially proven or available. This aim would be to complete demonstration and development, lower costs and deploy across the sector. Available innovations will have to be analysed and prioritised in terms of cost, technology “readiness” and potential emissions reductions performance. This could involve steel companies, design institutes and technology vendors/manufactures. This could form part of the government assistance to the sector to achieve a sector no-lose target. These demonstrations could be integrated into a sectoral approach to both demonstrate the effectiveness of the incentive and to lower the average emissions intensity of the sector.

Regularly disseminate information and raise awareness among iron and steel companies of the benefits and procedures of CDM and future mechanisms.

Promote engagement with voluntary disclosure projects to raise awareness among sector of carbon liabilities.

5.2.4 Services

Improve laws to strengthen ESCO business models and develop clear MRV guidelines for energy performance contracts to avoid disagreements over actual savings and who is responsible for their achievement. Specialist engineering firms or ESCOs could be trained to install, operate and maintain certain emissions reductions technologies to remove technical bottlenecks preventing deployment.

Glossary

Energy saving and emissions reductions technologies

Technology	Description
Coke Dry Quenching (CDQ)	Using cold and combusted waste gas to exchange heat with hot red coke in CDQ furnace for cooling red coke. After absorbing the waste heat, the heat generated by exhaust gas will be transferred to waste heat boiler and generate steam, the cooled inert gas is induced into CDQ furnace through circulating air fan to cool red coke. The medium voltage (or high voltage) steam is produced in waste heat boiler, which may be used to generate power.
Top Pressure Recovery Turbine (TRT) generating systems	TRT is one of the most important energy recovery technologies for iron and steel enterprises. Using the waste pressure and waste heat resulting from the top gas of the blast furnace, to transmit gas into turboexpander, making the pressure energy and heat energy transform into mechanical energy to drive a generator to generate power.
Converter Gas Recovery and Efficient Utilisation Technology	At the same time as recovering flue gas generated by running BOF electrostatic precipitator (ESP) purification, the gas is recovered; the collected dust will be used as coolant for converter on its return after hot pressuring. It may partially or fully compensate the consumption in converter during the steel-making process.
Recycling of blast furnace gas power generation	Recovery of released blast furnace gas to generate electricity.
Combined Cycle Power Plant (CCPP)	CCPP is the combined set of gas cycle and steam cycle equipment. The released waste gas produced by the gas turbine will be recovered by the waste heat boiler to generate steam and then generate power.
Inverters or VSD (on fans, pumps, compressors, drives etc)	In order to ensure the production safety, a certain amount of margin will normally be reserved when designing Power Drive. Installing an inverter may rapidly accommodate the load change and supply the maximum efficiency of voltage, leading to energy saving. It may be applied to motors, fans, pumps and air compressors.
Red Hot Charging	This is a production process involving cutting the hot billet produced by continuous casting machine into size-requested, and then directly sent to rolling mill for temperature control or directly sending into heating furnace for heating and rolling. Using this technology, the yield of heating furnace may be obviously increased and the heating quality may be improved, the fuel consumption of heating furnace might be reduced, the burning damage of the continuous casting billet can be reduced, and therefore, to improve yield.
Sintering cogeneration technology for iron and steel industry	The flue gas produced by the sintering equipment, hot gas furnace, steelmaking and heating furnace may generate steam through the waste heat boiler of high-efficient and low-temperature (using flue gas and waste heat of 200 to 400°C to drive turbine-generator unit to generate power.
High temperature air combustion technology (HTAC)	A type of combustion technology. Combining the technologies of waste gas recovery and high efficiency combustion, as well as NOx emissions reductions technology to bring pre-heating temperature of air and gas up to 1000°C or even higher.
Pulverised Coal Injection (PCI）	PCI is an advanced EE technology, substituting coke with coal and optimising the structure of blast furnace iron-making consumption.

Financing mechanisms for energy saving and emissions reduction projects

Mechanisms	Description
Commercial bank loans	A standard monetary loan from a commercial bank (the lender) to a customer (the borrower). The loan may be a secure loan in which the borrower pledges some asset as collateral for the loan or unsecure. Repayments are agreed over a set timeframe applying a given commercial rate of interest on each repayment.
Factoring	Factoring is a financial transaction whereby a business sells its accounts receivable (i.e., invoices) to a third party (called a factor) at a discount in exchange for immediate money with which to finance continued business. Factoring differs from a bank loan in three main ways. First, the emphasis is on the value of the receivables (essentially a financial asset), not the firm's credit worthiness. Secondly, factoring is not a loan – it is the purchase of a financial asset (the receivable). Finally, a bank loan involves two parties whereas factoring involves three. (In the case where the bank acts as factor then only two parties are involved). In China, current factoring cooperates with ESCO to engage EE project.
Financial leasing	A finance lease or capital lease is a commercial arrangement where: • the lessee (customer or borrower) will select an asset (equipment, vehicle, software); • the lessor (finance company) will purchase that asset; • the lessee will have use of that asset during the lease; • the lessee will pay a series of rentals or instalments for the use of that asset; • the lessor will recover a large part or all of the cost of the asset plus earn interest from the rentals paid by the lessee; • the lessee has the option to acquire ownership of the asset (e.g. paying the last rental, or bargain option purchase price). The finance company is the legal owner of the asset during duration of the lease. However the lessee has control over the asset providing them the benefits and risks of (economic) ownership. Financing leasing may be combined with ESCO mechanism to implement EE projects.
Energy Service Company (ESCO) – also referred to as Energy Management Company (EMC) in China	An energy service company (ESCO or ESCO) is an enterprise providing a specialised or range of comprehensive energy solutions. The ESCO performs an in-depth analysis of the customer's building, factory or system, designs an energy efficient solution, installs the required equipment, and maintains the system to ensure energy savings during the payback period. The savings in energy costs is often used to pay back the capital investment of the project over a set period, or reinvested into the project to allow for capital upgrades that may otherwise be unfeasible. If the project does not provide returns on the investment, the ESCO is often responsible to pay the difference. The ESCO will pay for the design, installation and operation of the equipment and will recover the original investment and required return from the cost saving. ESCOs may share the saving. ESCOs may us banks loans, or leasing to finance projects. ESCOs form energy performance contracts (EPC) with their customer to guarantee the paybacks and payments based upon the permanence of the energy saving projects according to an agreed specific technical and operation criteria.
Clean Development Mechanism (CDM)	The CDM allows emission-reduction (or emission removal) projects in developing countries to earn certified emissions reduction credits, each equivalent to one tonne of CO_2. These CERs can be traded and sold, and used by industrialised countries to a meet a part of their emissions reductions targets under the Kyoto Protocol.

Mechanisms	Description
	The mechanism stimulates sustainable development and emissions reductions, while giving industrialised countries some flexibility in how they meet their emissions reductions limitation targets. The projects must qualify through a rigorous and public registration and issuance process designed to ensure real, measurable and verifiable emissions reductions that are additional to what would have occurred without the project. The mechanism is overseen by the CDM Executive Board, answerable ultimately to the countries that have ratified the Kyoto Protocol. In order to be considered for registration, a project must first be approved by the Designated National Authorities (DNA). Operational since the beginning of 2006, the mechanism has already registered more than 1,000 projects and is anticipated to produce CERs amounting to more than 2.7 billion tonnes of CO_2 equivalent in the first commitment period of the Kyoto Protocol, 2008–2012.

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References

China Energy Research Institute (ERI). 2009. *2050 China Energy and CO_2 Emission Report*.

China Iron and Steel Association, 2007

China National Development and Reform Commission (NDRC). 2008. [Online] Available at: http://www.sdpc.gov.cn/zcfb/zcfbgg/2008gonggao/W020080617578776095360.pdf [Accessed 20 January 2010].

China National Bureau of Statistics, 2009 [Online] Available at: http://www.stats.gov.cn/tjsj/ndsj/2008/indexee.htm [Accessed 20 January 2010].

Chinese Government. 2007. [Online] Available at: http://www.gov.cn/flfg/2007-10/28/content_788493.htm [Accessed 12 December 2009].

Chinese Government. 2008. *2009-2011 Plan for the Adjustment and Revival of Iron and Steel Sector in China*, [Online] Available at: http://www.gov.cn/zwgk/2009-03/20/content_1264318.htm [Accessed 12 December 2009].

ESCO Committee of China Energy Conservation Association (EMCA). 2009. S*urvey of members 2008.* (Personal communication, 18 September 2009).

European Commission. 2001. *Integrated Pollution Prevention and Control (IPPC) Best Available Techniques Reference Document on the Production of Iron and Steel*

European Union Chamber of Commerce in China. 2009. *Overcapacity in China Causes, Impacts and Recommendations.* [pdf] Available at: http://www.europeanchamber.com.cn [Accessed 20 January 2010].

International Energy Agency (IEA). 2008. *World Energy Outlook 2008.* [pdf] Available at: http://www.worldenergyoutlook.org/2008.asp [Accessed 20 January 2010].

Nippon Steel Corporation. 2009. *Nippon Steel Sustainability Report 2008.* [pdf] Available at: http://www.nsc.co.jp/en/eco/report/pdf/english_2008.pdf [Accessed 20 January 2010].

World Steel Association. 2009. [Online] Available at: http://www.worldsteel.org [Accessed 20 January 2010].

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