# POTENTIAL ROLE OF SECTORAL APPROACH (SA) FOR CARBON EMISSION REDUCTION IN INTERNATIONAL CLIMATE MECHANISM

## CASE STUDY ON THE IRON AND STEEL SECTOR IN CHINA

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# 1 Research Background

The Bali Roadmap, approved in the thirteenth Convention of Parties under the United Nations Framework Convention on Climate Change (UNFCCC), encourages the employment of "cooperative sectoral approach (hereinafter referred to as SA) and sector-specific action" as technological transfer and major emission reduction methods. SA and its contract models have drawn broad attention for their potential roles in emission reduction. However, based on current research, it will be a complicated task to integrate SAs and contract models in certain industries of different countries and integrated them into an international climate change mechanism.

Although there are some studies on SAs and related issues at both domestic and international level, we still need to make more efforts to explore and solve relevant problems about the implementation of SAs. There are lots of issues to be considered, including SA types, boundaries, and elements of SAs, data requirement and availability, potential roles of SAs in international climate mechanism, SA implementation in different counties, how to integrate SAs into the international climate system and bring their potential into practice, the relationship of SA and international carbon market, etc.

At present, some domestic and international research institutes have conducted case studies on SAs in the steel, power and cement sectors. However, there are still differences in how SAs are understood, and on how SAs may be implemented by different sectors in different nations and regions, and whether SAs can realize emission reduction potential and contribute towards stabilizing the global GHG concentration level. he report from the World Steel Association indicates that iron and steel sector is one of key industries in term of both carbon emission and mitigation. Currently, the iron and steel (I&S) sector accounts for 5% of the global carbon emission caused by fuel combustion, and is expected to grow by 50% in the coming thirty years.

The I&S sector is a fundamental industry for China's national economy. By using top-bottom and bottom-top methodologies, domestic research institutes come to the conclusion that by 2020, I&S sector in China will exceed the production of 700 million tonnes which account for more than 45% of the global market. Over the past 10 years, I&S sector's energy consumption accounts for 12% to 15% of total energy consumption and energy consumption per unit added value (energy intensity) is more than 3 times of the average level of the whole industry sector in China. Energy intensity of China's I&S sector is more than 10% higher than the international average advanced level. By 2020, the technological carbon reduction potential in China's iron and steel will be about 300 million tonnes CO2. As a result, I&S sector will be the largest industrial sector in GHG emission reduction in China. I&S sector will play an important role for China to achieve its 40%~45% carbon intensity reduction target by 2020.

In order to research on issues like the feasibility of SAs, its diversity in different counties, how to integrate SAs into international climate system and how to play its role, Climate Strategieshas organized research institutes from India, China and Japan to conduct case studies on SAs potential roles and their implementation mechanisms for I&S sectors.

The aims of this study are:

- to be more aware of the development of SAs in international climate system,
- explore the nature of SAs,
- understand the GHG mitigation potential of the I&S sector in China;
- possibility and feasibility of SAs in I&S sector in China,
- analyze the implementation issues of SAs and their potential influence on the I&S sector in China

# 2 General introduction and assessment of sectoral approach in I&S sector in China

## 2.1 Overviews of researches on sectoral approach in China

Within this study we consider the common Chinese understanding of a sectoral approach: that it will lead to carbon emission reduction using a market-based approach[1] with an aim to provide the incentive for carbon reduction on a sectoral level, rather on a company level or project level. The objective of proposing such an approach by international society is, on one hand, helping expand and bring into consideration of all carbon reduction efforts around the world, especially those of developing countries, and on the another hand, encouraging more domestic carbon reduction actions within the scale of a country. Until now, SA is only a negotiating subject under the UNFCCC framework as a potential post-2012 mechanism to address climate change.

For China, SA can be taken as a method to show the willingness and contribution to adopt national appropriate actions to mitigate climate change, which is very important and crucial for some energy intensive sectors such as I&S sector. It can be also regarded as an important contributing option for I&S sector to achieve the national carbon reduction target announced by Chinese government in Nov 2009. However, it is not yet clear for definition, contents, standard and implementation framework of implementing such an approach in I&S sector, in that there are several different proposals on possible SAs. As a result, it is of importance to enhance the study on the possible appropriate SA and its implementation within the I&S sector.

Up to now, generally speaking, the research on SAs in China is very limited. There are some studies on SAs in China conducted by different organizations and institutes including ECOFYS, Energy Research Institute, China Iron and Steel Research Institute, Tsinghua University, etc. Most of these studies focused on general assessment of SAs and the related emission reduction potential of given SAs, but not on how to implement it under a feasible framework, especially for a given sector, like I&S sector in China. Nevertheless, some researches has touched upon the basic principle and framework of SAs and begun to analyze key issues including data and baseline, which are very crucial for the implementation of SAs in China. For the I&S sector, based on the overview of these researches, it could be concluded that although the I&S sector is more complicated than other sectors in some aspects (for example the production process and product category), which makes it more difficult to implement SA, the low-cost emission reduction potential in I&S sector is relatively high. As a result, the I&S sector is regarded as a good candidate sector for China to pilot SA as an option to achieve the national carbon intensity target, under the condition that the related problems such as data availability and quality and baseline setting can be resolved. Of all possible SAs, the intensity SA target is analyzed in many researches as an appropriate form of SA, but there are still a lot of problems that need to be considered and solved in advance. The descriptions of general results of these studies are shown as below.

*(1) Research by Ecofys and ERI*

From January 2009 on, Ecofys and Energy Research Institute of NDRC work together to do a road testing for SA in power sector, cement sector and transportation sector in China. They make an assessment of "no-lose" sectoral target in the above three sectors. The definition of "no-lose" target is that China voluntarily admits to reduce carbon emission in given sectors and achieve a "no-lose" intensity reduction target. If more reduction can be achieved, the additional reduction can be traded in the market. Meanwhile, China will not be punished even if the target is not achieved.

In this project, they think it is a key to set a sectoral baseline for the achievement of "no-lose" sectoral reduction target. In order for that, the project team use a tool developed by Ecofys to make an assessment on the baselines for three sectors individually. The carbon emission intensities of three sectors are then projected under three different scenarios, i.e. baseline scenario, sectoral no-lose target scenario and enhanced reduction scenario, in order to enhance the understanding on the baseline of SA and the related problems such as data availability.

It is found that through the project analysis result that China has good basis for the implementation of SA, but a good data basis open for monitoring, reporting and verifying should be established to set an appropriate no-lose target. For this purpose, the capacity building in local region and sector should be

[1] Note that technological improvement could be included within this definition, providing it led to the generation of carbon credits.

enhanced and the r incentive scheme such as sectoral approach should be developed to drive reduction actions.

*(2) Research by CAMCO and ERI*

In 2009, CAMCO and Energy Research Institute of NDRC work together to make a comprehensive analysis on potential mechanisms to finance and deliver GHG emissions reductions in I&S sector in China in post-Kyoto period. In this project, different SAs are compared and assessed through the surveys on relevant stakeholders, in order to enhance the understanding of benefits of different potential SAs and the problems they might have during the implementation in I&S sector. Many questions are raised in this project regarding different SAs and some solutions are also given based on the pilot survey and interviews with government officials, researchers, steel companies, and so on. A number of recommendations from perspectives of mechanism, finance, awareness and services are also given in the project report.

*(3) Research by WathanyuAmatayakul et al.*

WathanyuAmatayakul et al. undertake an analysis in 2008 to propose a method for formulating national sectoral baselines and sectoral no-lose crediting targets for the electricity sector for seven developing countries including China for post-2012, assess the amount of emission that could be reduced compared to the baselines through options of increased efficiency of fossil power plant and decreased share of fossil electricity and estimate the amount of emission reduction credits that could be generated based on the proposed target. In the project, a unit of g CO2/KWh is used as an index to assess the emission intensity in power sector, and China has a downward baseline. Besides baseline target, several enhanced reduction targets including fixed crediting target, dynamic crediting target, and ambitious target are designed to assess the emission intensity reduction in different scenarios. In the scenario with highest reduction effort, the national average carbon intensity of China in 2020 would be decreased by 15% compared to that in 2005, and the total annual average emission reduction credits for China would amount to around 300Mt/year.

Based on the results, it is found that the sectoral crediting target could provide substantial incentives to make a significant reduction of emissions in the electricity sector. China's government can assign the amount of generated credits to each relevant stakeholders that contribute to reducing the national average carbon intensity based on own mitigation policy and technology options. Substantial efforts from both private sectors and governments in these countries are needed to make radical emission reductions in the electricity sector.

*(4) Research by China Iron and Steel Research Institute*

Mrs. Zhang Chunxia from China Iron and Steel Research Institute assessed issues regarding with SA in I&S sector, especially in China, in 2008. She addressed that SA may be the supplementary for general national emission cap for developed countries and also the efficient way for developing countries. Benchmarking is regarded as a possible useful tool for implementing SA. However, as she thinking, since I&S sector is more complicated than other sectors, it is crucial to set appropriate indicators to implement SA in I&S sector, even though it is very difficult to obtain a comparable methodology. Moreover, data is another difficulty for I&S sector to implement SA in that there are many problems for data availability and reliability, transparency, monitoring, reporting and verification. She suggested do some pilot projects, set technology roadmap and detailed benchmarking method, and adopt a flexible and diverse framework to help facilitate the implementation of SA in I&S sector in China.

*(5) Research by Tsinghua University*

WenjiaCai*et al.* in Tsinghua University assessed the emission reduction by SA from different sectors in China. According his study, it is concluded that 1106Mt CO2 can be reduced at maximum in 2020 in SA, with no consideration of cost acceptability. Many sectors can have big potential to reduce carbon emission by low cost. For example, in I&S sector, the emission reduction achieved by options costing lower than 10US$ per ton of CO2 will take account of 22% of total carbon emission reduction potential. By considering factors such as existence of low-cost mitigation opportunities, it is found that transport, cement and I&S sectors could possibly consider involve in SA, but will need a deeper assessment of the comprehensive effects. If more aggressive mitigation goals are set, a sharp increase in sectoral mitigation cost will usually happen and without technical and financial help from international community, such goals can hardly be met by China.

## 2.2 Options of proposed SAs

Based on the relevant studies, SAs can be divided into different categories. When considering the crediting or allocation method, there are two broad mechanisms by which SAs can be used to tie monetary value to emissions reductions achieved within a sector:

- *Ex-post* crediting of emissions reductions, where emissions reductions have no value until they are verified after the event and shown to qualify for a credit. The companies of sector can then obtain the economic award based on the credit (i.e. certificated additional emission reduction)
- *Ex-ante* allocation of emissions permits, where emissions allowances are distributed in advance and surplus can be sold on an internal or international market.

Regardless of the crediting or allocation method, the means for measuring the emissions reductions generally falls into one of three types of metrics:

- Emissions intensity where emissions are normalized per unit of output within the sector;
- Absolute emissions quantity where a fixed total volume of emissions is predefined;
- Technology targets whereby emissions reductions are calculated from targets based on levels of technology penetration.

Not all combinations of these crediting mechanisms and measurement metrics are possible and some have been excluded from the international debate for being too complex to implement. This information is summarized in the following Table.

**Table 2.1: Feasible SA options based on the combination of different categories**

| | Emissions intensity | Absolute emissions | Technology targets |
|---|---|---|---|
| *Ex-post crediting* | Sectoral crediting | No-lose fixed national baseline | Technology crediting |
| *Ex-ante allocation* | Too complex | Cap-and-trade scheme | Not applicable |

## 2.3 Assessment of SAs for I&S sectors in China

It is shown in Table 2.1 that the only appropriate crediting method for SAs based on emission intensity and technology targets is ex-post crediting, while for SAs based on absolute emission reduction, both ex-post and ex-ante allocation are feasible. Nevertheless, currently the ex-ante allocation method is more acceptable in the global society as it is more clear and direct for promoting and implementing emission reduction activities, though it is not easy for developing countries to express political inclination on it.

### *2.3.1 Ex-ante SA based on absolute emission reduction (Cap and trade scheme)*

From Table 2.1 it is clear that the only practical form of ex ante allocation is a cap-and-trade scheme based on absolute emissions across the whole sector. This is widely considered to be the most advanced type of SA whereby a binding mandatory cap is placed on a whole sector and emissions permits are allocated amongst installations. Many developed countries already have already implemented or are in the process of planning such schemes. The European Emissions Trading Scheme (EU-ETS) is essentially a similar approach covering a number of sectors all together. Though this type of SA is promoted by a number of developed countries as a desirable end-goal of SAs to reduce emissions in developing countries, it is generally accepted that this is too ambitious for most developing countries to commit after 2012 without first committing to approaches without binding caps on absolute emissions.

An *ex-ante* scheme has to operate on a fixed absolute emissions basis and cannot be linked to emissions intensity. In order to fully play the role of this scheme in driving carbon reduction, the price of allowances in the market must be maintained at a high enough level to incentivize reductions; this can only be achieved through the setting of a stringent cap at the sector level. This is likely to be politically sensitive in developing countries such as China. In addition, when allowances are distributed as a form of 'currency' dependent on emissions data, the reliability of data provision becomes a very critical issue. The implementation of such SA in I&S sector in China will still face some challenges in three aspects.

- Generating sufficient political will to impose caps on a sector that could impact economic growth and development is a key problem that is unlikely to be accepted by both central government also sector decision makers.
- With no previous experience of any SA in the sector, the crucial step of calculating the correct target level (cap) for the whole sector would be challenging. Allocation method for distributing allowances is open to lobbying and political intervention, especially if there is no history of SAs in the sector in question.
- Developing data quality through MRV requires extensive capacity building and awareness in the sector. EU-ETS shows that developing a scheme where participants manage emissions allowances effectively takes some years to operate smoothly.

### *2.3.2 Ex-post SA based on emission intensity target*

To measure reductions based on emissions-intensity requires calculation of emissions per unit of output of the sector. This in turn requires very precise definition of output from the sector, which is a complicated matter for integrated industries such as iron and steel production. Once the metric is established, crediting can be established either at a national or installation level. It is unlikely that an ex-ante allocation system would be used with emissions intensity because this would need an ex-ante allocation of absolute emission based on an intensity index, which is quite complex and uncertain and also very complex to operate practically at a national level Therefore emissions intensity is most likely to be applied using *ex-post* crediting.

A national sectoral crediting mechanism (sometimes known as SCM) would involve a national Government being rewarded if the emissions intensity for an entire sector is lower than an agreed target. This would require a number of steps involving both the national Government and individual installations in the sector:

- A baseline based on historical trends must be established using past production and emissions data. This would use an agreed intensity metric such as $tCO_2$/tonne product or t $CO_2$/MWh electricity generated.
- A target level of emissions intensity must then be established and, if the mechanism is to generate internationally-accepted carbon credits, agreed by the UNFCCC process. The target emissions intensity must be a significant improvement on both the projected historical baseline and improvements expected from currently initiated policies and measures within the country. For I&S sector in China, this should include targets which affect energy saving and emission reduction such as capacity expansion (which lowers average intensity) and the mandatory closure of smaller blast furnaces (which will lead to a corresponding drop in emissions intensity).
- The sector as a whole will only receive credits if the government can show *ex-post* that the emissions intensity on average is lower than the target. This is demonstrated in figure 2.1 below. Figure2.1 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 emission-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 emission-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 emission intensity achieved are additional to that which would have occurred anyway.

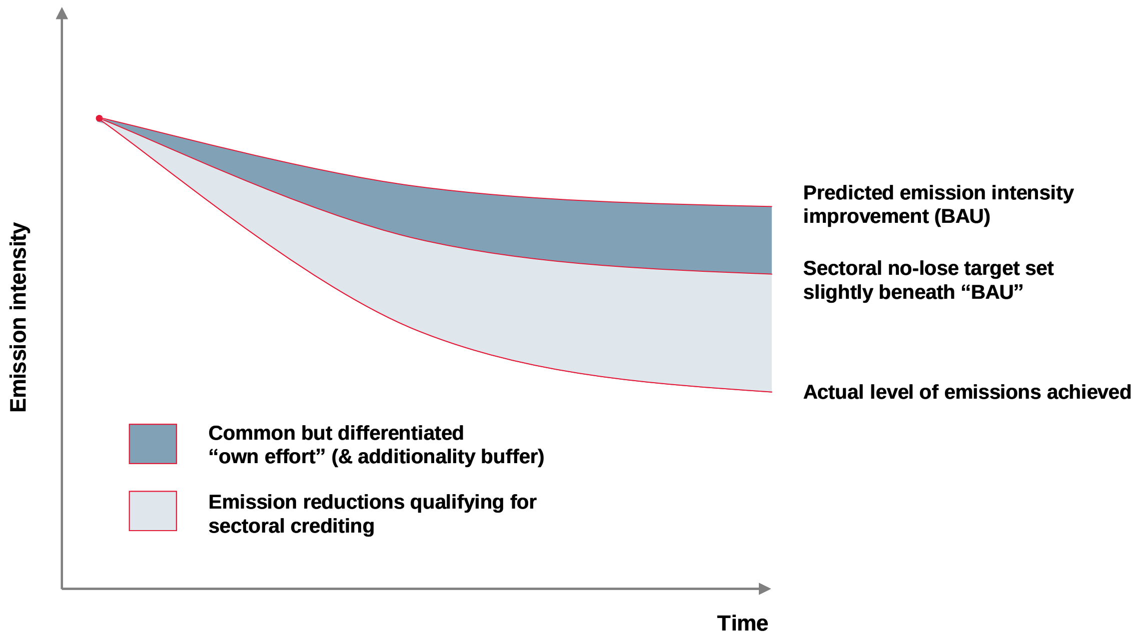


**Figure 2.1: BAU, Sectoral and actual emission reductions**

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 penalized 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. However, there are still some problems and barriers for Chinese I&S sector to fully adopt such a SA.

- Defining sector boundary and the agreed unit of output: The sector must be defined precisely – this is not trivial for a complex industry such as iron and steel and may require dramatic simplifications. For example, we couldrestrict the sector's involvement to only blast furnace operations, which could help ensure data comparability and catch the main potential for emission reduction potential in iron and steel production process, though it might lead to lose some opportunities for emission reduction in other processes.
- Ensuring availability of required data: Both the required datasets must be gathered and processed reliably from the entire sector (or all but an immaterial minority). To reliably calculate projected baselines, this must also include historical data. In China, the size and complexity of I&S sector means that this data will be hard to gather and process for the entire sector. Full engagement with iron and steel companies is crucial to ensure this, and engagement is more likely the clearer the perceived benefits of the system are.
- Lack of direct private sector performance incentive: The incentive for emissions reductions does not act on sector participants themselves, but relies on the government distributing credits to well-performing installations after the data from the entire sector are processed and verified. One challenge confronting governments looking to effectively implement a sectoral crediting mechanism is how to allocate credits when there is highly heterogeneous performance across a sector. An installation that is well below the target intensity may be offset by a small number of very large plants that perform very poorly and have a strong influence over the sector average intensity. In this case the Government must decide how to reward the good plants even if it receives no international credits for the sector as a whole. A penalty system for poor performers is one possibility, but this could be politically difficult to implement. Another challenge exists on an I&S sector heavily skewed by a few good performers in a growth industry. In a rapidly growing sector, commissioning of new, highly efficient plants to provide the increased capacity could have a strong effect on the sector average, with these new mega plants receiving credits even if they were business-as-usual choice and leaving no incentive for older, less efficient plants to reduce emissions.

*2.3.3 Ex-post SA based on technology penetration target*

Recently some major developing countries, including China, have put forward the notion of technology based SAs, whereby emissions reductions are calculated based on penetration of a particular low-carbon technology within a sector.

Under this approach, countries could accept targets for achieving emissions reductions associated with a certain level of penetration of technology and enterprises can obtain certificate if they applied technologies listed in this scheme.. Past data could be used to calculate, on average, how well one technology performs in terms of emissions reductions, so the corresponding emission reductions target could be quoted in tones of $CO_2$ as per other targets. A simpler means of using technology targets would be to continue China's policy of 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.

Clearly this mechanism is more applicable and implementable for China because it is easier to define the boundary and not necessary to undertake the site-by-site monitoring, reporting and verification. Meanwhile, it can help to promote the transfer of world advanced technologies to China. Nonetheless,

- It will be a significant challenge to such an approach to ensure that technology performs as expected and so will in reality be having the desired outcome in reducing emissions. For many technology types there is controversy over how emissions would be reduced because performance can be very heterogeneous amongst sites and type of installation, so detailed performance criteria would need to be established. In order to ensure this, it is crucial to develop an effective monitoring, reporting and verification system that credibly links roll-out of technology to robust emissions reductions, but this will bring more complexity for this approach.
- Developing an effective technology list that credibly links with robust emissions reductions would be a challenge. The Government would be required to manage complicated lists of technologies across many different sectors. Even within one sector, such as iron and steel, there would be a huge number of technology types to consider in the lists. The requirement of list qualification criteria may stifle innovation as new, immature low carbon technologies may be excluded and therefore dis-incentivized.

## 2.4 Appropriate SA options identified by this project

By comparison, technology-based SA might be most attractive for Chinese steel companies and government, as it can be implemented straightforwardly with minimum cost on economy growth and less complexity. Although there are some problems for this approach as mentioned above, they 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. As for environmental effectiveness, although it may exclude some emissions reductions potential under this approach, it could nevertheless cover key sources of carbon emissions. Therefore, from perspective of applicability and practicability, it could be a good approach to keep track of funding, technology improvement and carbon mitigation comprehensively. For this SA, it is essential to monitor and assess the impacts of this approach. When calculating carbon reduction resulting from the approach, the method of minimum emissions reductions can be used to make the projects comparable.

The intensity-based SA with a "no-lose" sectoral target imposed on I&S sector is also an applicable and feasible SA options for Chinese steel sector, despite that whether this approach be successful or not largely depends on some basic factors such as boundary setting, baseline setting, good-quality data availability, etc. There have been my researches studying on this approach, which approved its high potential to drive the carbon emission reduction in I&S sector. Nevertheless, an appropriate model is still needed to properly calculate the no-lose target and baseline. As in this approach incentives might be distributed unevenly in the sector, a flexible mechanism should be adopted to re-allocate government credits across the sector to ensure that active enterprises can acquire the proportional awards.

In summary, currently, the exploitation on possible SA options in I&S sector in China is still in a pilot and trial progress, so the selection of these different SA options should in large degree depend on the condition and situation it will be implemented on. A combination of different SA options might be a choice, which can distinguish among steel enterprises and deliver sufficient incentive to make the transition to less carbon emission. Furthermore, in order for a better implementation of SA in I&S sector, importance should be given in the short term to the data monitoring, reporting and verification, based on which the appropriate approach can be adopted in the long term.

# 3 Analysis of SA application in the iron and steel sector of China

## 3.1 Methodology choice and related technological issues

### *3.1.1 The selection of appropriate SAs*

After preliminary analysis, we find that regarding SAs at the international level, there are some issues which are difficult to define and solve, such as how to coordinate the interests of different countries, how to deal with the relationship of SA with global carbon reduction goals and liability sharing, how to consider national situations, etc. Without the solution of these issues, international SAs will lack operability and thus wil find it difficult to gain approvals from governments.

Therefore, we restrict our research subject to SAs at the domestic level, i.e., establishing reduction mechanisms between domestic industries or within one domestic industry to promote the realization of carbon reduction goals and the promulgation of long-term climate change strategies. By this restriction, we can avoid the political problems involved and the complex mechanisms for interest coordination and distribution caused by international SAs, and keep an eye on technological details in future SAs to approach an applicable and practical model for pushing forwards SAs.

In this project, we hold that ex-post crediting approach based on carbon intensity reduction targets is suitable for the I&S sector in terms of reduction methodology, after comparing several potential reduction methodologies probably used in the I&S sector, including cap-and-trade approach based on absolute emissions, emission reduction trade approach based on carbon intensity and emission reduction trade approach based on technology level target.

When it comes to baselines of emission reduction methodologies, the choice of carbon emissions intensity targets are more easily accepted by enterprises and the governments, and also easily connected to China's 2020 carbon emissions intensity target (40%-45% reduction of carbon intensity from that of 2005). From the perspective of the enterprise, although it will raise higher requirements on data acquisition and data quality, such a target is more easily accepted, because it can take into account the development of enterprises, energy saving, low-carbon and transition together. From the perspective of implementation modality, ex-post crediting approach can produce enough incentives as well as be better connected to mitigation policies and measures at the national level, as well as, avoid too much pressure on industries.

### *3.1.2 System boundary setting of SA in I&S sector*

The process of I&S production is complex and there are various types of enterprises with relatively large differences in iron and steel sector. Owing to this, selecting appropriate system boundary is an important prerequisite for the implementation of sectoral approach. Boundary setting also affects enterprises' emission calculation by considering both comparability between enterprises and data availability. Therefore, the setting of system boundary must follow the principle that it should cover majority of the sector's emissions and take into account the current situation of enterprises in energy consumption statistic and their capabilities in emission calculation.

Through comparison and analysis, we found that product selection has great impact on boundary setting in I&S sector. Major part of energy consumption and carbon emissions in China's I&S sector happens in pre-crude-steel production process. According to this, the system boundary is set to those enterprises using converter and EAF to produce crude steel, which is consistent with industry association's statistics system and can account for 90% of the nation's crude steel productions. At the same time, $CO_2$ emission per unit product (crude steel) is selected as the indicator to estimate carbon emission reduction target for iron and steel sector.

For China's I&S sector, energy consumption per ton of steel (including comprehensive energy consumption per ton of steel and comparable energy consumption per ton of steel) is a comprehensive index and can reflect comprehensively the situation of iron and steel sector in China, including technology structure, raw material route, technology and equipment level, penetration degree of advanced technologies, energy consumption structure and quality, recovery and utilization of energy resources, energy efficiency level, effect of relevant policies and measures, etc. How these issues change will have direct and indirect influences on $CO_2$ emission intensity. On this account, energy consumption per unit of product (crude steel) is the basis of calculating and evaluating $CO_2$ emission per unit of product (crude steel).

In addition, the crude steel is a typical product for the analysis and evaluation of energy intensity and $CO_2$ emission intensity, with a good comparability among different countries and different enterprises in a country. Thereby, it is a good indicator to be monitored, reported and verified. Meanwhile, based on this indicator, it is relatively easier to determine the potential of energy saving and emission reduction, on the condition that national future steel demand, mitigation technologies and policies and measures are estimated, either through projections or other methods

However, for China and other developing countries, there is considerable uncertainty for the future development of I&S sector. Crude steel production might be dramatically increase or decrease, which will affect on the judgment and determination of emission reduction target for the sectoral approach. At present, in China, the analysis about various factors affecting steel output and the statistics with regard to relevant quantity indicators are quite weak, which will affect the accuracy of energy intensity target.

### *3.1.3 Baseline setting of SA in I&S sector*

After defining system boundary, we need to define the baseline. The baseline reflects emission (or emission intensity) trends in iron & steel sector under certain conditions, representing a reference value for emissions (or emissions intensity) in the future. By comparing the baseline and actual emission trend, we can estimate the effects of efforts on carbon emission reduction and accordingly provide incentives to different enterprises.

There are various ways to set baseline, but for Chinese I&S sector, the baseline must be able to reflect effects of existing policy and measures, which implies a trend of improving sectoral performance and aims to encourage enterprises to reduce more than required by the central government. Of course, this will need to consider emission reduction potential capable to be achieved, otherwise it would bring too much pressure on enterprises, and ultimately affect emission reduction effect, leaving sectoral approach merely a formality without practical emission reduction.

Based on the above discussions, our project attempts to use the carbon emission per ton of steel as the target to set the dynamic sector credit baseline and calculate the corresponding potential $CO_2$ emission reduction credits of China's iron & steel sector in 2020 and 2030, which will be built based on the scenario analysis of energy demand and carbon emission in I&S sector in China from 2005 to 2030.

### *3.1.4 Technologies and policies & measures influencing emission reduction in I&S sector*

The development practices of China's iron and steel sector show that technological progress contributes a lot to the industry's energy saving and emission reduction, and it will still be, along with stock turnover, a key driving force to achieve emission reduction potential in next 10-20 years. Our study will further consider main technologies that promote the future emission reduction, including existing technologies and new technologies that might be taken in the future.

Besides technologies, various policies & measures are also important factors driving emission reduction in iron and steel sector. They included both national- and sectoral-level policies and measures related with carbon emission reduction in iron and steel sector. For example, such policies as the requirement to eliminate backward production capacities and financial and tax incentives encouraging energy saving and emission reduction belong to macro-level policies, and on the contrary, other policies such as energy efficiency standard, energy consumption quota, energy management standard are sectoral-level policies. In addition, our analysis will also clarify the impacts and roles of command-and-control measures as compared with market-based mechanisms. Finally, our analysis will consider the impacts of implementing international climate flexible mechanisms such as CDM on sectoral approach.

### *3.1.5 Other issues of SA in I&S sector*

Due to the lack of data and information, it is unable to do the assessment in this project on the costs of emission reduction technologies and those impacts on enterprises' investment cost. In addition, constrained by the limited understanding and awareness of stakeholders involved in the implementation of sectoral approach, it is also unable to discuss operational issues in this project, such as the definition of implementation bodies, implementation method, potential connection with carbon market, combination with CDM, funding mechanism, key elements, institutional arrangement, etc.

## 3.2 Main driving force for the further development of China's I&S sector

The iron and steel industry is fundamentally important for China's economic development. China's crude steel production in 2009 is 568 million tons, accounting for 46.6% of the global production. The output and the added value of the industry account for 8-9% of the total industrial output and added value. Energy consumption accounted for 25% of total energy consumption. Over the past 10 years, iron and steel industry's energy consumption accounts for 18% to 25% of total energy consumption; energy consumption per unit added value is more than 3 times of the average level in Chinese industry. Energy intensity (per ton steel) of China's iron and steel industry is more than 10% higher than the avareg level of the world's major steel-producing countries. Results from domestic research institutions show that Chinese steel demand will be more than 700 million tons and 900 million tons in 2020 and 2030 respectively. Therefore, the iron and steel industry will have the largest potential GHG emission reductions from any industrial sector in China looking forward. The iron and steel industry will play a crucial role if China is to achieve its 40% to 45% carbon intensity reduction target in 2020.

Iron and steel industry is an important foundation for China's economy and the pillar industry for achieving industrialization. Economic growth, large scale urbanization and foreign trade will be main driving forces for the further development of China's iron and steel industry.

*(1) Large scale urbanization*

China's urbanization scale will be very significant in the world. According to Chinese Academy of Social Sciences, the scale of urbanization, either in concern of annual net increase or the total urban population, will be top of the world for a long time period. As of 2009, China's urbanization rate had reached 46.6%, the total urban population had reached 620 million, as 2 times the total U.S. population and more than a quarter higher than the total size of EU-27 population. It is expected that in the next 5 years to 10 years, urbanization in China will enter a period of accelerated development period. The urbanization rate will be 62% in 2020 and will continue to reach to 70% in 2030. The urban expansion will require more urban infrastructure, public facilities and construction of residential buildings. These will all increase China's steel demand significantly.

*(2) Rapid economy growth and the industry shifting from coastal areas to inland China*

China's rapid economic growth and the industrial upgrading will also promote the industrial shifting from coastal areas to inland China in the same period of urbanization. Chinese governments will promote various incentives to encourage people move from much more developed and coastal cities to second and third class cities and also encourage industrial upgrading and the industrial echelon transfer from coastal areas to inland China.

For example, Foxconn will set up a new industrial park in Zhengzhou, Intel closed the factory in Shanghai but make the expansion of its production base in Chengdu, HP set up its notebook computer export production base in Chongqing, Unilever is brewing a new factory in Hunan. Electric appliance manufactures like Haier, Gree, Midea, TCL have plan or have already started new production base in the inland areas. The increasing construction for cities and infrastructure in the western and medium provinces will request a large scale of investment on construction, including housing, industrial plant, public facilities, as well as machinery, transport equipment, automobiles, highways, railways. The investment and related construction will be an important factor for the growth of iron and steel industry in the next 10 to 20 years in China.

*(3) Strong increase of foreign trade*

Due to global financial crisis in recent years, demand for Chinese goods in the US and Europe hasbeen weakened. The corresponding growth rate of China's merchandise exports fell in 2009. China's net export of steel reduced from 51.84 million tons in 2007 to 2.36 million tons in 2009. In addition, because current national policy does not encourage the export of steel products directly, and also the protection of foreign trade in some foreign countries, China's steel export become more difficult. But the indirect export of steel is still a lot of potential in the future, such as the export of mechanical equipment, generators, automotive, shipbuilding, refrigerators and air conditioners.

The above three factors provide a big increase for the demand growth of Chinese steel, and the strong driving force and continuity of this rigid demand is unmatched by any country. Currently, studies show that the 2020 and 2030 crude steel demand in China (including exports) will be more than 700 million tons and 900 million tons respectively. Some industries statistics show that China's current crude steel capacity is about 700 to 800 million tonnes per year. The actual production capacity will be even less than this under normal circumstance which lags behind comparing to the expectation of more than 900 million tons of crude steel demand,. Due to factors like the limits of domestic energy resources, raw materials, logistics, and in particular, greenhouse gas emissions and environmental protection, also taking into account the national strategy to speed up the reconstruction and the upgrade of the iron and steel industry. China's crude steel demand will rely on both domestic and foreign markets.

## 3.3 China's steel production and demand in future

Iron and steel industry is an important foundation for China's national economy and also an industrial pillar to achieve industrialization. Driven by strong market demand, China's iron and steel industry develops rapidly. In 1995 blast furnace iron production in China is just more than 100 million tons and it reached to 544 million tons in 2009, accounting for the world's production of 60.5% blast furnace iron. In 1996 China's crude steel output was just more than 100 million tons in 2009 and it reached to 568 million tons in 2009 accounting for 46.6% of the world's steel production. In 1998 China's steel output was just more than 100 million tons and it reached to 696 million tons in 2009. From 1996 to 2009, average annual growth of China's crude steel production is 14.2%, which has been top of the world for 14 years. Figure 3.1 shows the production and development trends of Chinese major steel products from 2000 to 2009.

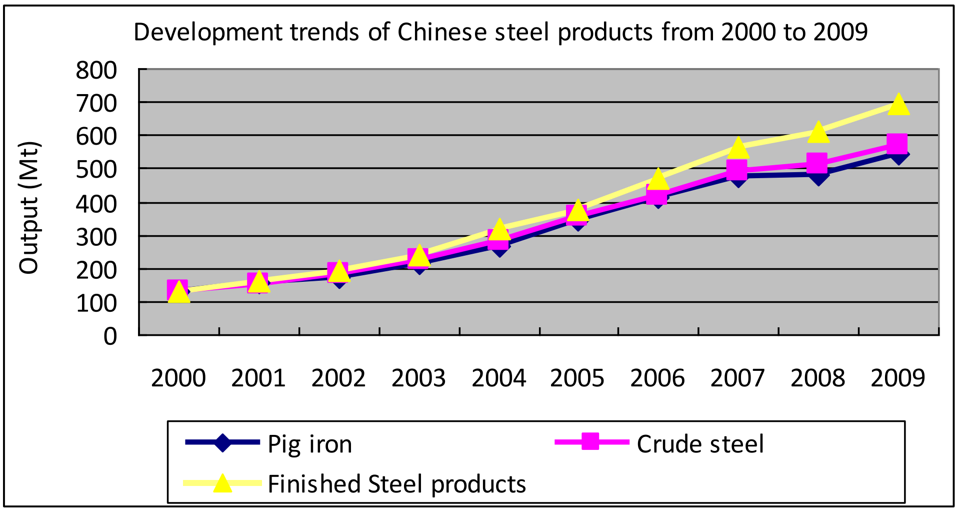


**Figure 3.1 Development trends of Chinese major steel products from 2000 to 2009**

Source: China Iron and Steel Statistics, 2009, China Iron and steel industry Association; China Statistical Abstract, 2010, China Statistics Press

The statistical data of World Steel Association shows that in 2009 the crude steel production of the world's 66 major steel producing countries and regions was 1.199 billion tons, decreased by 8.1%. Among them the EU-27 countries, CIS, North America and Japan decreased by 29.7% 14.7%, 33.9% and 26.3% respectively, while Asia and China increase 3.8% and 13.5% respectively. Steel production of the world's major steel-producing countries in 2008 and 2009 is shown in Figure 3.2.

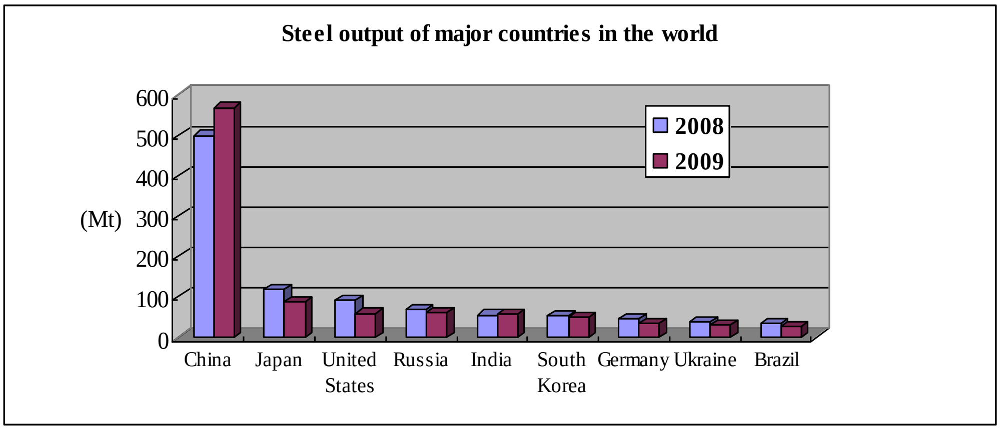


**Figure 3.2 Steel productions of the world's major countries in 2008 and 2009**

Chinese steel consumption structure has distinctive Chinese characteristics. In 2008, building sector accounted for 49.5% of total steel consumption; machinery, automobile, transportation, metal, shipbuilding, steel manufacturing and home appliances accounted for 41.1%; other sectors accounted for 9.4%. The steel consumption structure will maintain the same in next 10-20 years in China.

In ERI's report "China low-carbon development path in 2050: Energy Demand and Carbon Emission Scenario Analysis", detailed analysis have been made for China's future industrial development and also main drivers for the development. According to the report, in order to achieve the "three-step" socio-economic development goals from the present to the middle of this century, China's GDP will maintain a sustained and rapid growth. With the acceleration of industrialization, industrial growth rate will be higher than GDP growth rate before 2020 and will decline slowly after 2030. Industrial added value will be maintained at about 47% of CDP and decline to 36 % in 2050. Due to per capita income growth, consumption structure will be upgraded. Due to the income growth, residential consumption structure will upgrade, demand for housing, vehicles and road infrastructure will be growing strongly and this will increase the demand for steel. Besides, the international trading will also increase China's demand for steel. Based on different scenarios, Chinese steel demand will be 710 to 860 million tons in 2020 and 680 ~ 960 million tons in 2030. Steel demand is estimated to peak somewhere in the period from 2005 to 2030 (see Figure 3.3).

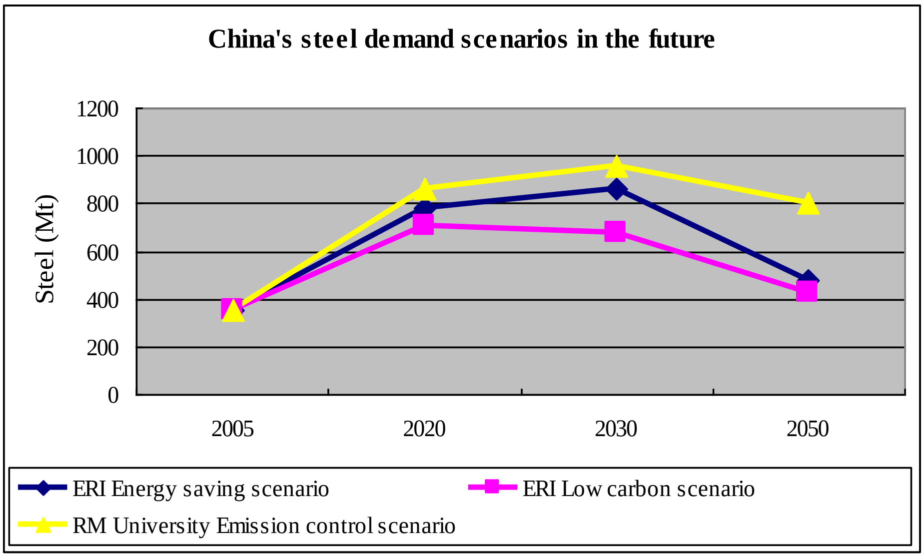


**Figure 3.3 Steel demands in China under different scenarios**

## 3.4 Energy consumption and greenhouse gas emission in China's I&S industry

### *3.4.1 I&S industry's energy consumption and energy efficiency*

Iron and steel industry is the most energy-consuming industry among various sectors in China's economy. The energy consumption increased from 1.6 million tce in 2000 to 4.35 million tce in 2008, with the average annual growth of 13.3%. The average annual growth of steel production during the same period was 19%. In the past decade, the share of energy consumption of iron and steel industry of China's total energy consumption increased from 13% in 2000 to 16% in 2008. Coal accounts for about 70% energy consumption in the sector. The per unit energy consumption of the added value of Iron and steel industry is more than 3 times of the average level of China's industrial sector. Energy consumption changes of the iron and steel industry from 2000 to 2008 is shown in figure 3.4.

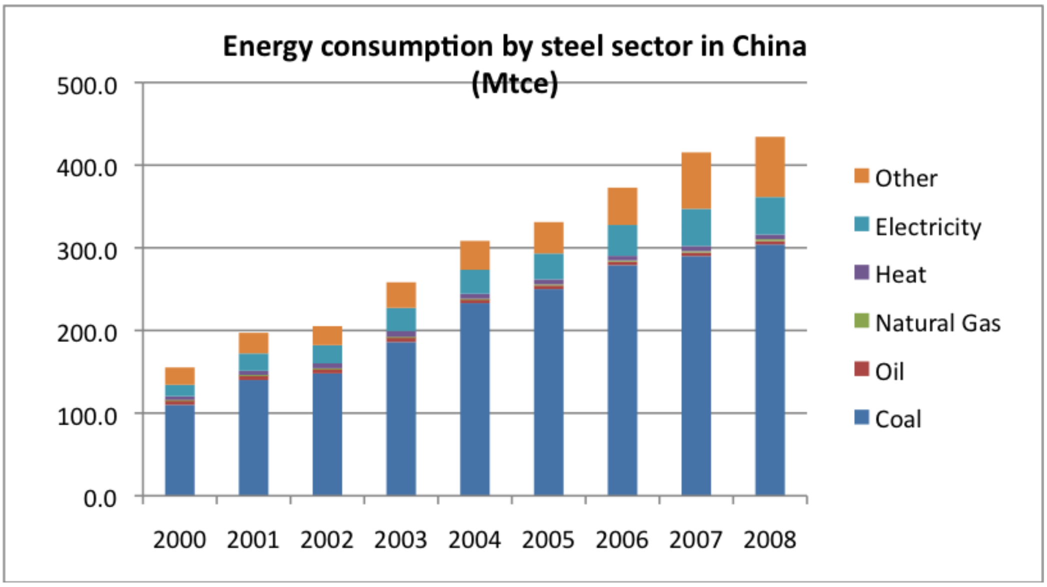


**Figure 3.4 Energy consumption changes in I&S industry from 2000 to 2008**

Since 2000, quite a lot of efforts have been made by China's steel industry to promote new and energy efficient technologies like new type dry quenching (CDQ), coal moisture control (CMC),new type TRT, dry dedusting technology, waste heat power generation, gas-steam combined cycle power generation technology (CCPP), blast furnace hot oxygen coal injection technology, hot delivery and charging of continuous cast billet and direct rolling technology, and high efficiency heat storage technology etc. Together with stock turnover, this led to a 33% decline of comprehensive energy consumption of steel in China's major steel enterprise from 920 kgce / ton in 2000 to 619 kgce / ton in 2009. The comparable energy intensity per ton of steel decreased from 781 kgce / ton in 2000 to595 kgce / ton in 2009, with a rate of 24% decline. China's Baosteel has achieved the negative energy consumption in BOF steelmaking which is the international advanced level (China Steel Industry Yearbook, 2008).

Table 3.1 shows energy consumption changes in the industrial process of China's steel industry from 2000 to 2009. Over the past 10 years, energy efficiency increased fast in the process of converter steelmaking, electric furnace steelmaking and steel rolling process. There are still large potential for energy saving in iron making and coking processes. At present, energy consumption levels for the same processes can vary from 3 to 8 times between the most advanced enterprises and the worst enterprises (see Table 3.1), the comparable energy consumption per ton of steel of China's large to medium-sized steel enterprises in China is still more than 10% higher than the average level of the world's major steel-producing countries. Therefore, the I&S industry is akey area for improving energy efficiency and greenhouse gas emissions reduction.

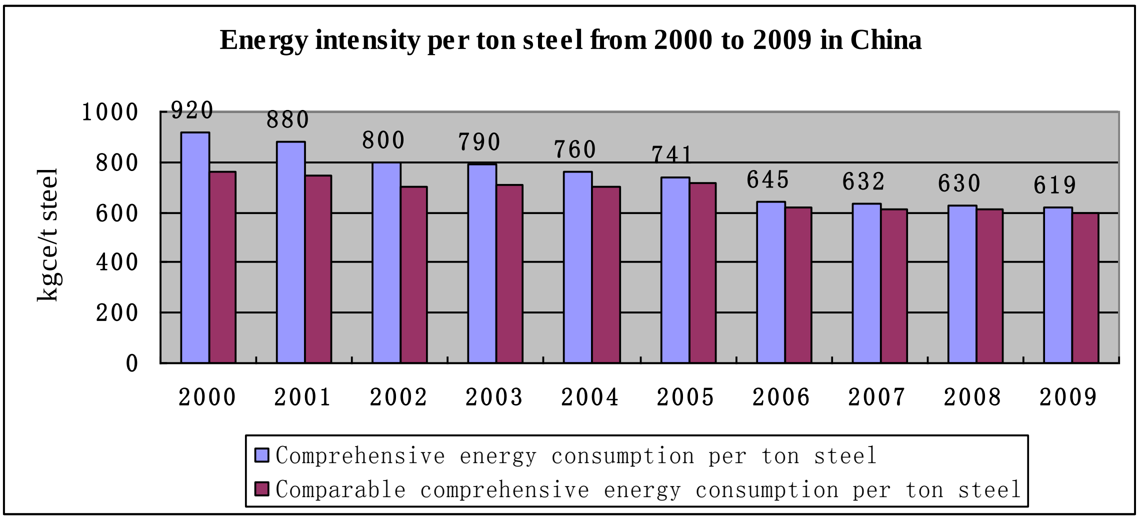


**Figure 3.5 Changes of comprehensive energy consumption[2] and comparable energy consumption[3] of major steel enterprises in China.**

[2] Comprehensive energy consumption per tonne steel = total energy use/total steel production

[3] Comparable energy consumption per tonne steel = energy consumed per tonne of steel, including the energy consumed by iron & steel in other production processes, energy consumption of fuel processing, transport and siron & steels's share of energy losses.

**Table 3.1 The process energy consumption of major steel enterprises (unit: kgce/t)**

| | Sintering | Pellet | Coking | Iron | Converter | EAF | Bar steel |
|---|---|---|---|---|---|---|---|
| 2000 | 68.9 | - | 160.2 | 466.07 | 8.88 | 97.59 | 117.95 |
| 2005 | 64.83 | - | 142.21 | 456.79 | 11.34 | 83.02 | 88.52 |
| 2007 | 55.47 | 30.12 | 126.89 | 428.28 | 6.32 | 80.94 | 59.52 |
| 2008 | 55.32 | 30.41 | 118.97 | 432.13 | 6.01 | 80.81 | 59.58 |
| 2009 | 54.95 | 29.96 | 112.28 | 410.65 | 3.24 | 72.53 | 57.66 |
| 2009/2000 Increase (kgce/t) | -13.95 | - | -47.92 | -55.42 | -5.64 | -25.06 | -60.29 |
| 2009/2000 Change (%) | -20 | - | -30 | -12 | -64 | -26 | -50 |
| Advanced enterprises in 2009 | Shougang 38.08 | Taisteel 16.21 | Jianlong 64.71 | Taisteel 353.89 | Taisteel -13.41 | Nanjing 23.23 | Shuisteel 24.22 |
| Poor enterprises in 2009 | 72.83 | 53.78 | 330.07 | 509.92 | 32.92 | 197.9 | 208.46 |
| | | | | | | | |
| | | | | | | | |

Source: summarized from related reports.

Key factors impactingChina's iron and steel industry energy efficiency include: energy consumption structure and quality, the scale of enterprises, raw material route, equipment, technology and equipment level, energy-saving technology penetration, recycle penetration etc.

*Long process converter steelmaking takes a big proportion*

In 2008, 31% of global steel enterprises use electric arc furnace technology, 67% use converter steel technology, and a small portion of enterprises use low efficient open-hearth plant technology. China eliminated open-hearth steelmaking technology in 2003, but long process converter steelmaking technology has been dominated China's steel industry for a very long time period. In 2008, China's total steel production was 512 million tons, 87.4% was from converter steel, 12.4% for electric furnace steel, 0.2 % from other technology types. According to China's iron and steel industry statistics, large to medium size steel enterprises produced 415 million tons of steel in 2008 (accounting for 81% of total production) 91.1% of which was from converter steel, 8.83% for electric furnace steel, 0.07% for the other types of technology. The proportion of electric furnace steel is much lower than the average level of 31% worldwide, leading to higher comprehensive per ton energy consumption nationally.

*A significant share of small equipment*

Large capacity blast furnace process can save coal by 50 kgce/t to80 kgce/t compared to small volume equipment. Gas recovery and vapor recovery equipments of small converter units have a much lower efficiency; large modern coke oven is more energy efficient than small and medium side facilities and can reduce environmental pollution; large modern sintering machine can save more than 30% of small sintering. The energy consumption of iron-making process accounts for more than 70% of total energy consumption of the steel production process. In China in 2008, the largest number of  blast furnaces were medium-sized. with  about 70% less than 1,000 cubic meters of blast furnace capacity and only 34% with a converter capacity of 100 tons or more.

*Penetration of energy saving technologies is still need to be increased*

There is still a big opportunity to further utilize new technologies like dry quenching (CDQ), coal moisture control (CMC),TRT, dry dedusting technology, waste heat power generation, gas-steam combined cycle power generation technology (CCPP), blast furnace hot oxygen coal injection technology, hot delivery and charging of continuous cast billet and direct rolling technology, and high efficiency heat storage technology etc. The penetration of these energy saving technologies is only around 30%.

*Waste gas, waste heat and pressure utilization rate*

Thermodynamically, 34% of the heat of coal used in steel production is transferred intoby-product gases (BF, BOF, coke oven gas). Recovery of converter gas and steam is crucial for achieving the negative energy production process. If the oxygen converter gas recovery process reaches to 100 m3 / ton of steel and then be used for comprehensive utilization, the converter process can save energy of 25kgce / t steel and achieve a negative energy. Japan steel enterprise Fukuyama has a 300 ton oxygen converter gas recovery facility which can reach the recovery amount of 113.1 m3 / t steel, which is around 80% of heat recovery in theory. At present, China's steel enterprises have more than 300 coke ovens, but 98 sets of CDQ equipment have been installed. The heat and steam recovery rate is only 50% of Korean Pohang Steel's level (262kgce / t). Nippon Steel can recovery 92% of the recyclable second energy, China's Baosteel can only recovery 68%, and most steel enterprises in China can recovery 50% or less. The second energy recovery has just started in medium and small enterprises. So it is clear that there is a great potential of waste recycling in iron and steel industry. The situation of recycle by-product gas last two years of major steel enterprises in China is shown in Table 3.2.

**Table 3.2 Recycle and utilization of by-product gas of major steel enterprises in China**

| | **Average** | | **Advanced** | | **Below average** | |
|---|---|---|---|---|---|---|
| | 2008 | 2007 | 2008 | 2007 | 2008 | 2007 |
| Blast furnace gas ventingrate，% | 6.01 | 9.99 | 0（14 enterprises） | 0（13 enterprises） | 22.19 | 65.65 |
| Converter gas recovery，m3/t | 65 | 63 | Taisteel 111 | Taisteel 108 | 0（12 enterprises） | 0（16 enterprises） |
| Coke oven gas venting rate，% | 2.25 | 2.79 | 0（19 enterprises） | 0（22 enterprises） | 22.6 | 15.09 |

Source: summarized from related reports.

*3.4.2 $CO_2$ emissions situation in China's I&S industry*

Due to the increase of production and energy consumption, greenhouse gas emission is also increasing. From 1990 to 2008, China's steel industry's direct emissions increased from 265 million tons to 1.13 billion tons, with a total increase of 3.26 times and the average annual increase rate of 8.4%. However, due to the increase of energy efficiency, per ton $CO_2$ emission of crude steel decreased from 4.06t in 1990 to about 2.2t in 2008, with a decrease rate of 46%. $CO_2$ emission growth index and per ton carbon intensity decline index of China's Steel Industry from 1990 to 2008 is shown in figure 3.6.

According to World Steel Association $CO_2$ emission of blast furnace - BOF process (long process) is about 3.5 times of the EAF process. Japan's steel industry studied $CO_2$ emissions of different processes for different steel products, results showed that deep processing products and high added value products have high energy consumption and $CO_2$ emission is also higher (see Table 3.3).

**Table 3.3 $CO_2$ emissions of different processes in Japan steel industry ($tCO_2$/ts)**

| | **Plain carbon steel** | **Special steel** | **Average** |
|---|---|---|---|
| BF-BOF | 2.127 | 2.298 | 2.152 |
| EA | 0.514 | 0,699 | 0.563 |

Source: summarized from related reports.

In October 2009, International Iron and Steel Institute publish a statement in the annual meeting in Berlin. The statement mentioned that China accounted for 51% of the world steel industry emission. China's steel industry has high energy consumption, and high $CO_2$ emissions. Main reasons include: China rely mainly on converter steel, accounting for 88%. The proportion of EAF steel is low (about 12%), much lower than the 27% in Japan, 40 % in EU's and 50% in the US; to a large extent this reflects the lower relative generation rate of scrap in China, which is still within its quick economic development phase. Since the energy consumption of electric furnace steel is only 1 / 3 of that of converter steel, the overall energy consumption and $CO_2$ emission are much higher in China. Besides, technology is relatively poor in China and more than

70% of energy consumption is from coal, both of these also result in high energy consumption and $CO_2$ emission. The main reason that China's average lags behind advanced countries is that it still has a number of small blast furnace and small converter. It also shows China's iron and steel enterprises are in the multi-levels, different techniques co-exist in the same period.

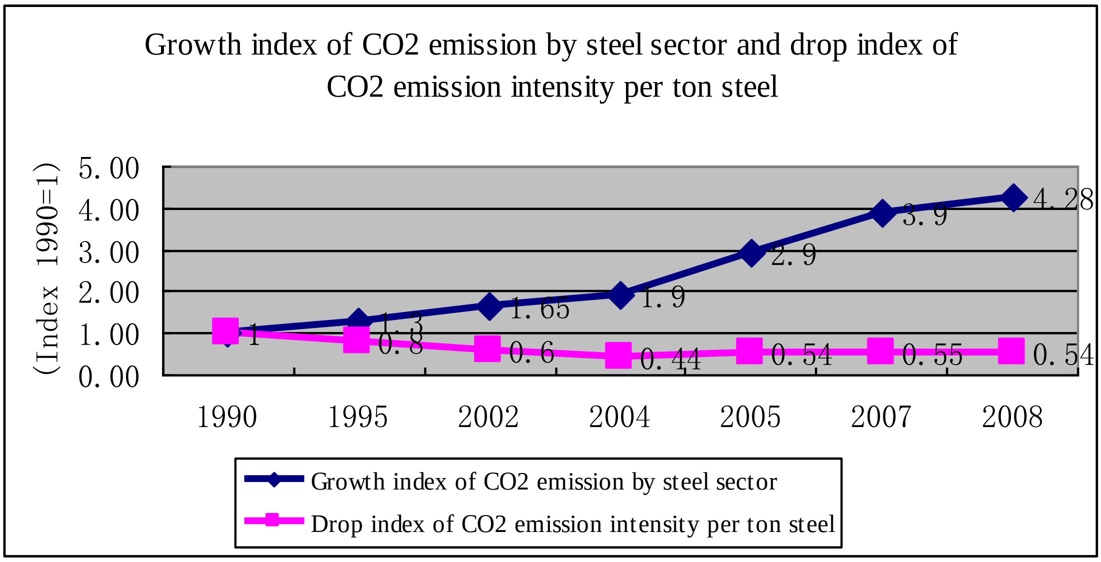


**Figure 3.6 $CO_2$ emission growth index and per ton carbon intensity drop index of China's Steel Industry from 1990 to 2008**

Based on the above analysis the main measures for China's iron and steel industry to improve energy efficiency and reduce $CO_2$ emission:

(1) Eliminate backward technology and equipment, and spread advanced technology to improve energy efficiency

(2) Recycle of production and pressure generated in the process, waste heat and by-product gas,

(3) Use scraps resources, increasing the proportion of electric furnace steel;

(4) To produce and use high-performance steel;

(5) Reduce fossil fuel consumption and find alternative energy sources;

(6) $CO_2$ capture and storage;

(7) Process innovation, develop new energy saving technology

### 3.5 Major technologies for emission reduction in China's I&S industry and their potential penetration

Steel industry is one of the most energy-intensive industries in China, and it also has higher implementation rates of energy saving technologies. I&S industry has already obtained good results in emission reduction. The implementation of some of best technologies is funded by the CDM mechanism. As of 2008, more than 13 billion yuan (approx. US$2 billion) has been invested in 21 CDM projects in steel industry which would achieve reduction of about 12.5 million tonnes per year. But there are still a big potential for further improvement of efficiency and reduce emission in the sector.

In recent years, quite a lot of new technologies have been broadly used in the large to medium size enterprises in the steel industry, such as TRT, dry quenching (CDQ), coal moisture control (CMC), dry dedusting technology, waste heat power generation, blast furnace hot oxygen coal injection technology, hot delivery and charging of continuous cast billet and direct rolling technology, and high efficiency heat storage technology, gas-steam combined cycle power generation technology (CCPP) etc. Some of these technologies have been included into NDRC's first and second "National Energy Technology Extension catalog" in 2008 and 2009 published the. Research reports and publications from ERI, Renmin University, IEA, McKinsey and other domestic and foreign research institutions provide a lot of detailed analysis of these technologies in different times and under different penetration scenarios, their reduction potential and mitigation costs.

Based on studies mentioned above, and various analysis of iron and steel industry energy technology status and development trends, information from governments and relevant industry associations and also academic publications, this report selected a few major technologies for emission reduction in 2030, their reduction rates and at different time and their potential penetration. The analysis is based on factors like technology advancement, energy saving potential, energy saving and emission reduction effect, emission reduction cost and sustainable competitive edge. Technological $CO_2$ emission reduction potential in 2020 and 2030 has also been estimated (see Table 3.4 and Table 3.5).

**Table 3.4 Major technologies for emission reduction in China's steel industry and their potential penetration**

| Key emission reduction technologies | Technical emission reduction rate (%) | Technology penetration（%） | | |
|---|---|---|---|---|
| | | 2005 | 2020 | 2030 |
| New type CDQ | 20~30 | - | 50 | 70 |
| CMC | 15~30 | 20 | 60 | 80 |
| Pulverized coal injection technology | 15~30 | 15 | 30 | 50 |
| New type TRT | 15~25 | 5 | 40 | 60 |
| Advanced large-scale blast furnace | 20~35 | 35 | 70 | 100 |
| Advanced large-scale coke oven | 20~35 | 20 | 50 | 70 |
| Blast furnace gas boiler | 30~40 | 5 | 30 | 50 |
| Converter gas dry recovery technology | 20~30 | 16 | 45 | 60 |
| Converter gas waste heat recovery and power generation | 30~40 | 15 | 40 | 60 |
| High-power electric arc furnace operation and oxygen blowing carbon injection technology | 30~40 | - | 10 | 30 |
| Large DC / AC electric arc furnace | 30~40 | 20 | 34 | 50 |
| Thin slab casting and rolling technology | 50~70 | 30 | 40 | 80 |
| Billet direct hot charging process | 20~30 | 40 | 40 | 80 |
| Regenerative furnace technology | 20~30 | 5 | 15 | 30 |
| CCPP | 20~30 | 10 | 30 | 50 |
| CCS in steel industry | 5~15 | - | 20 | 30 |

Source: HU Xiulian, Sectoral Technological Potentials to Mitigate Carbon Emissions in China, 2010.

According to this report, $CO_2$ emission reduction potential of maximize technology penetration scenario is 429 million tons comparing with the energy saving scenario in 2020. Major technologies as listed in table 3.2 can achieve 349 million tons of emission reduction by 2020, accounting for 81.4% of emission reduction potential. In 2030, $CO_2$ emission reduction potential of maximize technology penetration scenario is 603 million tons comparing with the energy saving scenario. Major technologies as listed in table 6.2 can achieve 465 million tons of emission reduction by 2020, accounting for 77.1% of emission reduction potential.

**Table 3.5 Technological $CO_2$ emission reduction potential of major technologies in China's steel industry (Continued Table 3.4)**

| Key emission reduction technologies | Absolute emission reduction potential (100 million tons $CO_2$) | |
|---|---|---|
| | 2020年 | 2030年 |
| New type CDQ | 0.5 | 0.2 |
| CMC | 0.1 | 0.2 |
| Pulverized coal injection technology | 0.2 | 0.1 |
| New type TRT | 0.25 | 0.3 |
| Advanced large-scale blast furnace | 0.3 | 0.3 |
| Advanced large-scale coke oven | 0.3 | 0.2 |
| Converter gas waste heat recovery and power generation | 0.15 | 0.3 |
| Converter gas dry recovery technology | 0.2 | 0.4 |
| High-power electric arc furnace operation and oxygen blowing carbon injection technology | 0.25 | 0.4 |
| Large DC / AC electric arc furnace | 0.4 | 0.8 |
| Thin slab casting and rolling technology | 0.15 | 0.3 |
| Billet direct hot charging process | 0.1 | 0.3 |
| Regenerative furnace technology | 0.2 | 0.2 |
| CCPP | 0.2 | 0.3 |
| Direct and smelting reduction technology | 0.1 | 0.15 |
| CCS in steel industry | 0.09 | 0.2 |
| | 3.49 | 4.65 |

Source: HU Xiulian, Sectoral Technological Potentials to Mitigate Carbon Emissions in China, 2010.

## 3.6 Policy and measures for promoting energy saving in China's I&S industry

In May 2008 and December 2009 NDRC issued two "National key Energy Technology Extension catalog". More than 10 technologies suitable for steel industry, are included: dry-type TRT technology, high pressure CDQ technology, sintering cogeneration technology, regenerative combustion technology, converter gas recovery and utilization technology, low heat value furnace gas - steam combined cycle power generation technology etc. The catalogue has already increased the popularity of these energy-saving technologies.

In addition to promoting energy-saving technologies, Chinese government has also issued a series of policies to promote energy conservation for iron and steel industry. For example, the Chinese government implements the policy to eliminate backward production capacity since 2005. By the end of 2009, 81.7 million tons of iron production capacity and 82.5 million tons of backward coke capacity had been eliminated. In April 2010, the State Council issued the "State Council's note on Further Strengthening the elimination of backward production capacity," which requires the industry to close all blast furnace below 300 cubic meters and converter and electric furnaces with the capacity no more than 20 tons before the end of 2010; and to close all blast furnace below 400 cubic meters and converter and electric furnaces with the capacity no more than 30 tons before the end of 2011. From 2010 to 2011, a total of about 100 million tons backward iron smelting capacity will be eliminated. This policy is much more specific and severe than previously issued measures (see Table 3.6).

In order to implement all policies discussed above, Chinese government takes a few useful practical measures, such as control the project approval, strict steel industry loans, strict tax collection and management, improve different electricity tariff, issue annual goals and tasks to eliminate backward production capacity, enhance the work of energy conservation measures, adjust the import and export tax policy of steel products etc.

**Table 3.6 standards for eliminating backward production capacity of China's steel industry since 2005**

| Date | Name of documents | Criteria for elimination backward production capacity |
|---|---|---|
| December 2, 2005 | "Industrial Restructuring Guiding Catalog" (2005) | 100-200 cubic meters (including 200 cubic meters) BF (alloy blast furnace is not included) (2005) 200-300 cubic meters (including 300 cubic meters) blast furnace (non-professional cast iron pipe plant BF is not included) (2007) |
| In the middle of June 2006 | "Note for the total capacity control, elimination of backward production capacity and speed up of the structural adjustment " | Eliminate blast furnace less than 200 cubic meters by 2007 close converter and electric furnace with capacity less than 20 tons. In total 2,255 tons of backward iron smelting will be shut down and 2,423 tons of steel making capacity will be closed. |
| March 23, 2009 | "Iron and steel industry restructure and revitalization plan" | Eliminate blast furnace less than 300 cubic meters by 2010, the total capacity will be 5.34 million tons. Close converter and electric furnace with capacity less than 20 tons, the total capacity will be 3.20 million tons. Close blast furnace less than 300 cubic meters, and converter and electric furnace with capacity less than 30 tons by 2011. In total eliminate backward iron smelting capacity of 72 million tons and steel making capacity 25 million tons. |
| April 6, 2010 | "Notes from State Council on Further Strengthening the elimination of backward production capacity " | Eliminate blast furnace less than 300 cubic meters by 2010, the total capacity will be 5.34 million tons. Close converter and electric furnace with capacity less than 20 tons, the total capacity will be 3.20 million tons. Close blast furnace less than 300 cubic meters, and converter and electric furnace with capacity less than 30 tons by 2011. From 2010 to 2011, a total of 100 million tons backward iron smelting capacity will be eliminated. |

### 3.7 China's I&S Industry's potential credits: $CO_2$ emission reduction potential in 2020 and 2030

In order to analyze the future credits which could arise from $CO_2$ emission reduction potential in the Chinese steel industry, the report makes four scenarios according to ERI's report published in 2009 "China in 2050 low-carbon development path: Energy Demand and Carbon Emission Scenario Analysis": business as usual scenario, credit baseline scenario, low carbon scenario and enhanced technology penetration scenario. Details are described as follows:

**Business as Usual (BAU) scenario:** China achieves most of its energy efficiency targets in 2005-2010 period but will not take specific measures to achieve the 40% to 45 % carbon intensity reduction target in 2020 China. Certain changes will be made on the economic development model; the scale of infrastructure construction will continue to be expanded; energy intensive production will maintain a high level in the near to medium period; steel production will peak in 2030; urban public transport system will be developed less than expectation, energy equipment manufacture, nuclear power and renewable energy industries have a certain development; breakthrough of major energy saving technologies are not significant; carbon capture and storage (CCS) technology penetration is not high; energy saving is still not very popular in the public; the development process does not completely eliminate the phenomenon of treatment after pollution; investment on energy-related technology will keep on increase; and a number of techniques will achieve the international advanced level.

In this scenario, China's I&S industry will keep a rapid growth rate from 2010 to 2030, steel production will peak in 2030 with production more than 860M tons; due to limited resource for energy efficiency, investments on new technological progress will not be fully guaranteed, and the elimination of ex-post production capacity will be limited in a small scale; I&S sector will make progress on emission reduction but the contribution on national emission reduction target will be limited. In this scenario, carbon emission intensity in I&S sector will be 2.2t $CO_2$/t steel in 2005, 1.95 $tCO_2$/t steel in 2020 and 1.90$tCO_2$/t steel in 2030.

**Credit baseline scenario**: different from BAU, in this scenario, I&S industry will be required to implement national policy of eliminating backward production capacity; the proportion of EAF steel production process will be slightly higher; CDM projects in I&S sector will be below 2010 level after 2015. In this scenario, China's carbon emission intensity in I&S sector will be 2.2t $CO_2$/t steel in 2005, 1.88 t$CO_2$/t steel in 2020 and 1.71 t$CO_2$/t steel in 2030.

**Low carbon scenario**: The Chinese government will continue to implement the mandatory emission reduction targets in the twelfth five-year plan from 2010 to 2015. While archiving the energy intensity targets, China will strongly promote the reduction of carbon intensity by 40%. More efforts will be made to change economic development models, production and consumption behaviors, strengthen technical innovation progress, promote renewable energy development and all other efforts valuable for achieving the carbon intensity targets. Especially, China has set up a strong renewable energy target to achieve 15% of renewables of total primary energy consumption. Also, CCS technology will be used in a fairly large scale, particularly in the power generation sector, and more investment will be provided for low-carbon economic development. In I&S industry the proportion of EAF steel will increase to 18% in 2020 and 20% in 2030. By then the carbon emission intensity in I&S sector will decrease from 2.2t $CO_2$/t steel to 1.62 t$CO_2$/t steel in 2020 and 1.4t$CO_2$/t steel in 2030.

**Technology penetration enhanced scenario**: In the low-carbon scenario, the penetration rate of advanced energy conservation technology will be increased, major breakthrough will be made on key low-carbon technologies, and costs of major energy saving technologies will be reduced fast. In this scenario, China's low-carbon energy will obtain better external development environment, research cooperation, new technologies development, capital inputs will all be put towards a low carbon direction; the use of international high quality energy will go smoothly. Meanwhile, the Chinese government will increase investment on the implementation of low carbon technology, clean coal technology and CCS. In iron and steel industry the proportion of EAF steel will increase to 24% by 2020 and continue to increase to about 30% in 2030. Extensive international cooperation will be conducted to introduce advanced technology. China will also actively develop CDM projects and participate into global carbon market. By then the steel emission intensity will decrease from 2.2t $CO_2$/t steel to 1.45t$CO_2$/t steel in 2020 and 1.22t$CO_2$/t in 2030.

The variation of carbon emission intensity in each scenario is show in figure 3.7.

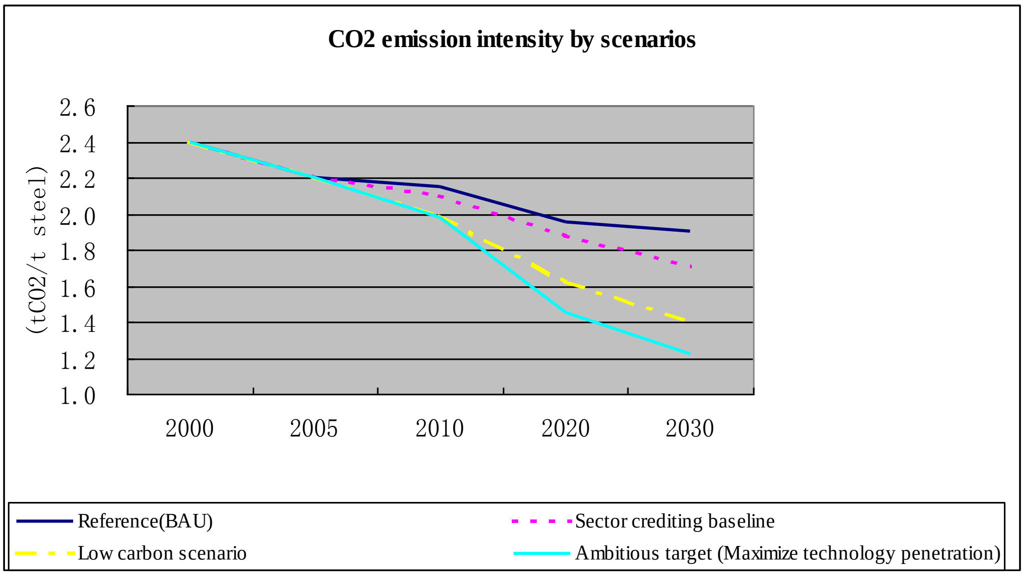


**Figure 3.7 Carbon emission intensity of I&S industry indifferent scenarios**

According to carbon intensity and the demand by then, credit $CO_2$ emission reduction potential is calculated as below:

Comparing with the credit baseline scenario, $CO_2$ emission reduction credits under low-carbon scenario will be 316 million and 436 million tons $CO_2$ in 2020 and 2030 respectively. Assuming the carbon price in the emission trading scheme is 50 U.S. dollars / ton, China's I&S industry will get 0.43 billion U.S. dollars and 0.59 billion dollars in 2020 and 2030 from sector approach based international carbon trading scheme.

Comparing with the credit baseline scenario, $CO_2$ emission reduction credits under technology penetration enhanced scenario will be 518 million and 709 million tons $CO_2$ in 2020 and 2030 respectively. Assuming the carbon price in the emission trading scheme is 50 U.S. dollars / ton, China’s I&S industry will get 0.71 billion U.S. dollars and 0.97 billion dollars in 2020 and 2030 from sector approach based international carbon trading scheme.

Besides, carbon emission reduction will also benefit the local level pollution control like $SO_2$ emission reduction.

## 4 Conclusions

（1） SA has both positive and negative sides. On one hand, SA is an effective market tool for mitigation in a systematic way and can be scaled up, and this is the advantage. On the other hand, as part of the climate change mechanism, it must follow the “common but differentiated responsibility” principle. In order to achieve greater emission reduction and lower cost, the promotion, application and diffusion of SA must base on this principle.

（2）Currently, China's concern on SA is mainly focused on SA concepts, how SA can be compatible with national and relevant government departments’ energy saving programs and policies, how SA can be combined with the on-going top-down and bottom-up methods of GHG emission reduction potential analysis in different sectors, emission reduction objectives, approach, cost, required investment and efficiency. Government departments, enterprises, research institutions are all participating in the organization of market-oriented methods to promote domestic emission reduction activities and the achievement of voluntary emission reduction goals.

（3）From now to 2030, China's I&S industry will be the industrial sector with rapid development speed and also relatively large potential for energy saving. Comparing to Japan and India, China's I&S companies are much more complex, with characters like large number of enterprises, product variety, different scale of enterprises, big difference among technology and energy efficiency levels in different companies. These will make many challenges for the implementation of SA in Chinese I&S industry. Major challenges include: industry stakeholders have quite different understanding of the SA approach; whether SA can be a practical and effective tool; how to identify the sector boundaries and outputs; how to obtain reliable and high quality data; how to avoid the impacts of the performance differences among enterprises ; how to establish monitoring, reporting and verification system; how to implement and manage SA; and whether the implementation of SA can promote emission trade and in the same time benefit the whole sector; how SA can contribute on China’s national macro-level emission reduction policies and the achievement of the emission reduction targets.

（4）All SA methods rely highly on the quality and reliability of the industry-wide data. It faces two problems: one is that data is not enough in company level; the other one is even the data is good in quality but may still be hard to be obtained due to the commercial sensitivity. This requires that corporate level participants to work together to explore: which kind of data can be obtained, whether the data is sufficient for the proper implementation of SA; how much data is publicly available and can be shared among enterprises, and this is also the prerequisite for the calculation of SA baseline. At present, China's energy and industrial statistics cannot meet the requirements. Therefore, there are quite a lot of problems need to be addressed about the statistic & index system, statistical methods, and also capacity building.

（5）Clean Development Mechanism (CDM) is a flexible mechanism to address climate change, and has already played a positive role for the promotion of $CO_2$ emission reduction in China’s I&S enterprises. By the end of 2008, China's steel industry has registered 21 CDM projects with the annual emission reduction of 125 million tones. Nevertheless, there are still a lot of potential CDM projects in China’s I&S industry. CDM will continue playing an important role for technological progress in China’s I&S industry.

（6）Based on the knowledge of SA the applicability of China’s I&S industry, we applied ex-post crediting approach based on carbon intensity reduction targets in this research. Crude steel product is identified as the industry border. We analyzed the trend of China's crude steel production till 2030 and possible changes in the mix of steel technology. A variety of technical and policy measures and their impacts on CO2 emissions were fully into took into account, of steel industry. The dynamic sector credit baseline was simulated in this research. We also estimated emission reduction credits in the low-carbon scenario and technology penetration enhanced scenario of China's I&S industry in 2020 and 2030.

Results show that under the low-carbon scenario, emission intensity of China’s I&S industry in 2020 will be 26% lower 2005, and will decrease by another 14% in 2030 comparing to 2020 level; emission reduction credit will be 316 Million tons and 436 million tons in 2020 and 2030. Under the technology penetration enhanced scenario Enhancement technology penetration scenario, emission intensity of China’s I&S industry in 2020 will be 34% lower 2005, and will decrease by another 16% in 2030 comparing to 2020 level; emission reduction credit will be 518 Million tons and 709 million tons in 2020 and 2030 respectively.

The implementation of SA in China’s I&S industry could further promote technology innovation, new technology introduction and development, and could also improve the industry's sustained competitiveness. How or to what extent the industry can obtain credit incentives will rely on the establishment and improvement of the SA mechanism, and also are related to the establishment, development and growth of China's domestic carbon market.

(7) Due to lack of data validity and time constraints, analysis of the cost of emission reduction technologies and required investment for the implementation of these technologies are not included in this research. Analysis of the potential impact of I&S industry’s emission reduction on China’s economic, social development and environmental protection are not included. The contribution of I&S industry on achieving the national emission reduction target in 2020 is not included.

(8) Finally, there are still some obstacles and difficulties in the implementation and realization of SA in China’s I&S industry, in particular, to overcome the methodological uncertainties, to establish the effective and practical implementation mechanism which can be supported by all domestic stakeholders, how emission reduction in I&S industry will be associated with the national emission reduction targets. In addition, the impact international level factors are essential, for example, the progress of global climate change negotiation and the implementation of international level feasible SA framework are very important for the implementation of SA in China.

# 5 Uncertainties and issues to be deeply explored

## 5.1 Study of the uncertainty

It is found through this project that due to the uncertainty of I&S industry’s boundary and credit baseline, the calculation of emission reductions credit are not accurate results.

The first is the uncertainty of the industry boundary. Comparing to the I&S industry in Europe, U.S. and Japan, China's I&S industry is still in the developing and growing stage, BOF is still the major technology, and energy efficiency levels are various among different enterprises and there is a big gap between advanced and backward companies. Due to continuous growth of the domestic and international demand, I&S industry’s production structure will change significantly. Companies will pursuit more high value-added products and improve their energy efficiency and emission performance. Therefore, if crude steel is identified as the boundary of I&S industry for SA, it will miss the promotion and abatement of high efficient technology in afterward process, and thus will affect the identification of credit baseline.

The second is baseline uncertainty. Penetration of various emission reduction technologies, implementation of various policy measures, effective implementation of energy efficiency standards and their effects are of significant difference in different companies in China’s I&S industry. Technology, raw materials route and product structures are also various among different enterprises. Because the statistic system is not well organized in China, it is difficult to reflect the impacts of these differences in the baseline identification process. Therefore, credit baseline which will base on the carbon intensity of I&S industry in China, will be of uncertainties, and will affect the estimation of credit emission reduction.

In addition, the future development of I&S industries in China and other developing countries will be of great uncertainty, crude steel production may show a substantial increase or decrease, and this will affect the industry when determining the emission reduction target. Whether the credit baseline study will be accepted by government departments, industry associations, research institutions and most of enterprises is also an important factor for uncertainty.

## 5.2 Issues to be deeply explored in the future

Further research on the methodology for the implementation of SA, in particular the consistency on the evaluation environment;

- How to improve the industry’s capacity on the preparation of greenhouse gas emission inventory and projections of greenhouse gas emission, how to establish and improve the ability of statistics of industry energy consumption and carbon emission;
- Enterprise level emission reduction potential, technology, and cost analysis;
- To stimulate all stakeholders to play their roles for implementation of SA, encourage government departments , research institutions, enterprises to participate in SA;
- Incentive mechanisms for the implementation of credit emission reduction;
- Monitoring, reporting and verification mechanisms of emission reduction activities under SA;
- To conduct demonstration of carbon trading;
- The implementation mechanism of SA.

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