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China Council for International Cooperation on Environment and Development (CCICED).

China's Low Carbon Industrialization Strategy

CCICED Task Force Report

CCICED 2011 Annual General Meeting
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Contents

Figures

Boxes

Tables

SUMMARY

Key messages

High and volatile resource prices as well as climate-related concerns have called into question the carbon-dependent development model across the world. This, together with the resurgence of interest in manufacturing in OECD countries, has changed the global competition landscape for emerging economies. The imperative of delivering alternative growth strategies is clearer than ever.

A Low Carbon Industrialization Strategy (LCIS) can address many of the critical challenges facing China – from employment, resource scarcities, energy security and climate change to demographic pressures. The LCIS will drive an evolution from the current investment-driven growth strategy in China towards innovation-led development.

Low carbon Industrialization will play a central and decisive role in achieving the national carbon intensity target for 2020. Of the needed reduction in carbon intensity, 95% will come from action in the industrial sectors: 42% from energy efficiency, 29% from structural change in the energy industry, 21% from changes in industrial structure and 3% more efficient use of resources.

In the short to medium term, seven traditional industrial sectors – electricity, steel, building materials, petrochemicals, non-ferrous metals, textiles and paper and pulp – can avoid 16.08 $GtCO_2$ between 2005 and 2020 through setting sectoral targets. There should be specific energy-intensity and conservation targets for each of these energy-intensive sectors.

Seven emerging pillar industries also have a key role to play in catalysing low carbon Industrialization in China: energy conservation and environment protection; low carbon energy technologies; low carbon energy vehicles; biotechnology; information technology; advanced materials; and equipment manufacturing. These provide support – whether in terms of technology or systems integration – to the movement by traditional sectors towards lower carbon growth. For example, by 2020 low carbon energy can help avoid emissions of 1.8 $GtCO_2$. China has already succeeded in industrializing and exporting some of the relevant technologies, contributing to a price reduction for renewable technologies in the global market.

Innovation lies at the heart of any large-scale industrial transformation, and is critical to delivering sustainable growth to 2020 and beyond. As well as investments in research and development, a comprehensive upgrade of the whole innovation eco-system is needed, with active hubs facilitating exchanges between different sectors, between public and private actors, and between China and the rest of the world.

The government can send strong and stable signals to the market through regulations and standard-setting for industries (such as Japan's Top-runner Program). Enforcement of regulation is key, as is meeting the need for monitoring and auditing. These measures should be combined with market-based mechanisms including price reform, carbon taxation and trade, as well as innovative finance to improve efficiency, internalize externalities and minimize costs.

Box 0-1: The Low Carbon Industrialization Strategy Task Force

This report was produced by the *Low Carbon Industrialization Strategy* (LCIS) Task Force of the China Council for International Cooperation on Environment and Development (CCICED).

The goal of the LCIS Task Force, established in 2010, is to provide a 10-year plan to promote the transition to low carbon Industrialization (LCI) in China by 2020, together with a longer-term industrial vision for the country. These are designed to support China's scientific development strategy, help to optimize its existing industrial base, promote the development of emerging industries and reinforce wider economic transformation towards low carbon production systems. The Task Force has also considered the regional strategy for and implications of LCI, reflecting the range of development characteristics and needs across China.

In parallel with the LCIS Task Force, a separate CCICED Task Force on the Green Economy (GE) has developed a strategic framework and priorities for greening the economy at the national policy level in China. The GE Task Force has a wider scope, assessing environmental opportunities and challenges throughout the economy, while the LCIS Task Force focuses on the role of industry in delivering a low carbon economy. The conclusions of the LCIS Task Force (see Chapter 5) are highly consistent with the headline messages from the GE Task Force, which are that China requires a fundamental change in values and perspectives on wealth and how it is created; a transformation of the role of the government so that it can lead and facilitate a well-functioning market; and a range of mechanisms to support innovation and encourage green production, investment and consumption, including building capacity and skills.

The LCIS Task Force builds on a previous Task Force on China's Low Carbon Economy (LCE), which reported in 2009 and proposed, among other recommendations, that China adopt carbon intensity improvement targets. It also highlighted the vital role of China's industry in meeting its LCE goals.

Many of China's overall goals for 2020, such as its target to improve the carbon intensity of the economy by 40–45% relative to 2005, were set out in or in advance of the 12th FYP. The LCIS Task Force is focused on the contribution of individual sectors – and their interactions – in the delivery of these goals, rather than revisiting the overall emissions and energy pathways.

Structure of this report

Chapter 1 sets out the trends that will help define the global landscape over the next 10 to 20 years, the critical period for China's low carbon Industrialization. A resurgence of manufacturing and focus on low carbon industries in key markets makes this a vital area for China's future competiveness. There is considerable international experience in promoting low carbon industries, especially in the past two decades. Strenthening China's innovation capacity and promoting an open an inclusive approach are the key to successful transition.

Chapter 2 provides an overview of China's industrial and energy situation, highlighting the strong foundation for taking a lead on low carbon industry but also the challenges that need to be addressed.

Chapter 3 explains that low carbon Industrialization is central to meeting China's broader objectives on the low carbon economy. The key dimensions are energy efficiency in industrial sectors, industrial restructuring and reorganization and the emergence of new pillar industries. In each area, innovation will become increasingly important over time.

Chapter 4 provides a detailed explanation of the role of seven energy intensive industries in low carbon Industrialization, underpinned by detailed technical analysis.

Chapter 5 assesses the potential of the seven emerging industries, including their role in supporting improvements in heavy industry and more fundamental restructuring of the energy and economic systems.

Chapter 6 presents specific policies and recommendations for China's low carbon Industrialization

1 INTRODUCTION AND INTERNATIONAL CONTEXT

Rapid Industrialization is integral to the growth strategies of many developing countries. Guided public and private investment into primary and secondary production – whether in steel, shipbuilding or metals processing – is also pursued by many other emerging economies today. However, environmental and resource constraints will make it increasingly difficult for the emerging economies to follow this 'traditional' pathway. As a result, the transition to a low-carbon economy presents unique challenges and opportunities for developing countries.

China is very much at the forefront of this search for a new, more sustainable model of Industrialization. As made clear by senior leaders in China, moving to a low carbon economy is of critical strategic importance as China evolves its development model, adjusts its economic structure, reinforces its technological base, and strengthens future growth potential. Sustainable Industrialization is a critical dimension of China's prospect for achieving future growth.

According to the International Energy Agency, a third of the world's energy consumption and 36% of carbon dioxide (CO2) emissions are attributable to manufacturing industries. The large primary materials industries – chemical, petrochemicals, iron and steel, cement, paper and pulp, and other minerals and metals – account for more than two-thirds of this amount. Overall, global industry's use of energy has grown by 61% between 1971 and 2004, albeit with rapidly growing energy demand in developing countries and stagnating energy demand in OECD countries. Despite their high emissions profile, global demand for hard-to-substitute goods like steel and petrochemicals is unlikely to fall rapidly over the next decade and beyond - the decisive period in the global response to climate change.

Today, a large share of China's economy is in a stage of Industrialization and urbanization marked by heavy chemical industries, the development of iron and steel, vehicle and ship manufacturing, and mechanical engineering industries, all of which require a large volume of materials and energy. The development of tertiary industry, with lower energy intensity, lags behind the world average by about 30 percent. On top of this, there are sharp regional variations in the degrees of Industrialization. China still needs to accomplish large-scale development in its western region.

Industrial energy consumption is roughly 70% of China's rapidly expanding economy, accounting for a large share of total greenhouse gas emissions today. These heavy industries have great potential to improve energy efficiency, and are the key to delivering China's important commitments on energy and carbon intensity in the next decade. Meanwhile the global picture for competitiveness is changing: Chinese firms hope to meet burgeoning global demand for low carbon technologies such as renewable energies, electric vehicles and green information and communications systems (ICT). China's 12th Five Year Plan shows that in the next ten years these low carbon sectors have the potential to become pillar industries, playing a central role in the economy. Meeting this goal depends on refocusing China's industrial assets and upgrading its capacities for technology innovation. Finally, shifting China's economic growth pattern and accelerating the process of economic restructuring is set to be an important strategic theme in the coming years. Green growth and low carbon industrial transition must be a key part of the solution.

Achieving the goal of industrial re-structuring is no mean feat, especially in the wake of the global economic downturn and increasingly volatile energy prices. Today, China's energy-intensive industries remain the pillars of the national economy. Employment pressures make it harder to speed up structural adjustment in the short term and close inefficient production capacity.

Across the globe, governments and businesses increasingly recognize that those that are moving fastest on low carbon transition will gain significant competitive advantage. According to HSBC, the low carbon energy market reached $0.7bn in 2009 and is set to grow to between $1.5 to $2.7 trillion in 2020.[1] By this time it may well exceed global military expenditure, which was at $1.6 trillion in 2010.[2] The key policy question is how states and markets can harness their industrial assets towards stimulating genuine opportunities in low carbon economic activities and energy efficiency investments across the globe.

The financial crisis of 2008 unleashed many questions for the future of the global economy. Perhaps more significantly, in the eyes of many, the crisis reaffirmed a global trend in the making over the past decade – that of shifting economic power across the globe, and the rise of several of these as major geo-economic actors in emerging economies. In 2010, China overtook Japan as the world's second largest economy in terms of nominal GDP, even though, at US$ 3,678, its per capita GDP is still one tenth of Japan's. This trend is accompanied by the growing role of governments in managing economic affairs following the economic crisis.

1.1 A changing global economic landscape

Trends in today's global economy will influence China's Industrialization pathway to 2020 and beyond. Since late 2008, governments across the world have engaged in comprehensive efforts to mitigate the near-term threats posed by a slow and uncertain global economic recovery, along with the longer-term threats posed by climate change, ecological pressures and higher resource costs. These developments are radically changing the context for development and growth for emerging economies.

China has emerged as a global player at a time of great uncertainty. Competitive advantages are shifting globally affecting how investment, industry, technologies and regions should be prioritized. The importance of manufacturing as a key driver of economic growth in the wake of the global downturn is cementing into a longer term trend, with low carbon technologies and services constituting some of the most promising markets. Indeed, the scale of investment and technology deployment required to meet international goals on climate and energy security strongly suggest that low carbon technologies will be decisive in shaping future competitiveness.

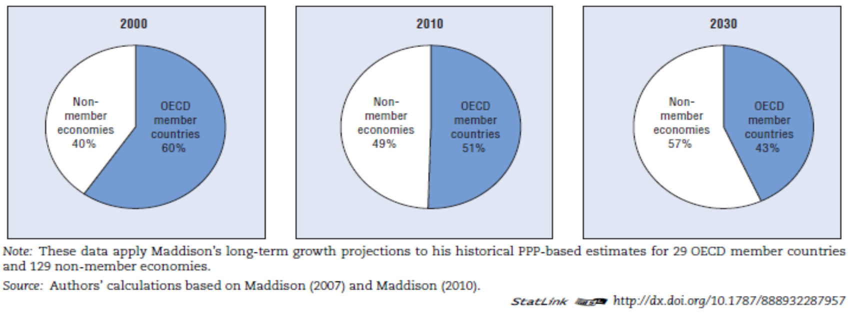
1.1.1 Shifting global economic trends

The developing economies continue their role as the driving force behind global growth since the financial crisis. Overall, these economies have weathered the recession - most countries posted only mild losses or escaped recession altogether. By the end of 2009, initial losses had been almost entirely recovered and these emerging economies continued to surge forward in 2010.

That this recovery was achieved under far more adverse external conditions is testament not only to the increased resilience of these economies, but also to the role of China as a regional life-saver. Although China suffered just as much from the drying up of world trade (in early 2009, Chinese exports were down 25% from previous year levels), its enormous fiscal room for manoeuvre allowed it to enact the (proportionally) largest stimulus plan in the world, fuelling a massive credit expansion which kept domestic demand growth high. This meant that the Chinese economy recorded yet another year of outstanding growth: 8.7%. On a regional level, Chinese demand kept imports from its Asian trading partners high. This effect was not just limited to Asia: China jumped to being Brazil's largest single trading partner over the course of 2009.

Emerging Asian economies have doubled their share of global output in the past two decades. According to Development Centre forecasts based on Maddison (2007 and 2010), non-OECD member countries as a group could account for as much as 57% of global GDP on a purchasing-power parity basis by 2030.[3] This shift of global economic wealth is not a transitory phenomenon, but one of global historic significance.[4]

Figure 1-1: Share of global economy in purchasing power parity term



Source: OECD (2010)

According to the OECD, a number of factors underpin this realignment. First, the opening of the large, formerly closed, economies of China, India and the former Soviet Union brought an additional 1.5 billion workers to the open market-oriented economy in the 1990s, creating a supply shock. This reduced the cost of many traded goods and services. It also created the condition for economic take-off in Asia. The growth in these countries also stimulated demand for many commodities like fossil fuels and industrial metals, transferring wealth to exporters in Africa, the Americas and the Middle East. As these economies grew, they moved from being net debtors to net creditors, which kept US and global interest rates lower than they might otherwise have been.[5]

However, according to Nomura, the assumption that Asian economies are decoupled from developments in the more advanced world seems to have been misplaced, notwithstanding the decades-long boom in Asian trade.[6] Nearly 40% of goods produced in Asia are destined for US, EU and Japan, and a collapse in demand from advanced economies can be felt throughout Asia. Indeed, one of the main casualties of the financial downturn was global trade. World trade loss amounted to $3-4 trillion in 2009, as compared to global GDP loss of $1-2 trillion.

In the near term there is the risk of a return to protectionist policies, which has been high on the international agenda since the financial crisis broke in 2008. The strong rhetoric at the G20 on fighting protectionist tendencies has not always been reflected in the actions of individual countries and the risk of an escalation in trade disputes remains. Analysis by Global Trade Alert suggests that nearly 1400 protectionist measures have been implemented since the G20 in November 2008.[7] WTO agreements, it says, have encouraged countries to channel protectionist pressures into policies not well covered by enforceable rules.[8]

China's economy remains heavily dependent on global trade and investment flows, something which was highlighted in 2008 when the global slump forced thousands of factories to close. Rebalancing the economy toward domestic consumption and accelerating the transformation of China's economic development model is a top priority for the 12th Five Year Plan.

In the absence of a comprehensive global deal on climate change, links between trade and climate change have been brought into focus in the debate over the potential for border adjustment measures (BAM). In the US and to a lesser extent the EU, carbon price adjustment at the border for imported goods is now being considered seriously as part of a broader climate policy package, although this has retreated in the US with the failure of major legislative proposals for cap and trade. Viewed narrowly as a response to competitiveness and carbon leakage concerns caused by carbon mitigation policies, BAMs make intuitive sense.[1] But moves in this direction are highly controversial, especially in developing countries which regard them as discriminatory. In principle, BAMs would be imposed on sectors in countries perceived to have failed to introduce carbon policies that are "at least as stringent" as the US, for example. In absolute terms, China would be the developing country most affected by such an approach. A BAM policy in the US or EU is likely to result in economic impacts that are significantly greater than the scale of recent trade disputes.[9] There is a risk that the political pressure resulting from a BAM could lead other countries to consider retaliatory trade measures.

1.1.2 The resurgence of manufacturing as a strategic interest

The state of manufacturing has become a key indicator of success for developed countries while their governments seek to stimulate economic recovery. The sector is perceived to be critical to long-term prosperity, growth and competitiveness. There is therefore a renewed focus on the role of governments in creating the conditions for a thriving manufacturing sector.

Many developed countries have bolstered their industrial policies and are pursuing more interventionist strategies. For example, the US launched *A Strategy for American Innovation: Driving Towards Sustainable Growth and Quality Jobs* in September 2009[10], The EU adopted *Europe 2020: A strategy for smart, sustainable and inclusive growth* in June 2010[11] and Japan announced details of its *New growth strategy by 2020* in June 2010[12] (see Box 1-1).

Box 1-1: Japan: New Growth strategy[13]

In mid-2010 the Japanese Government announced 21 National Strategic Projects for the revitalization of Japan for the 21st Century. These projects affected a wide variety of sectors, the energy sector, transport, urban construction, manufacturing and healthcare, to name but a few. Under the subheading of Green Innovation, three specific projects have been proposed:

Expansion of Japan's renewable energy market:

- Expand the purchase of renewable through the feed-in tariff system
- Introduce smart grids to make the system more efficient and enable the greater integration of renewables
- Promote the construction of renewables, through the creation of implementation zones.
- Provide financial assistance to strengthen finance mechanisms
- Create renewable heat demand.

Future Cities Initiative:

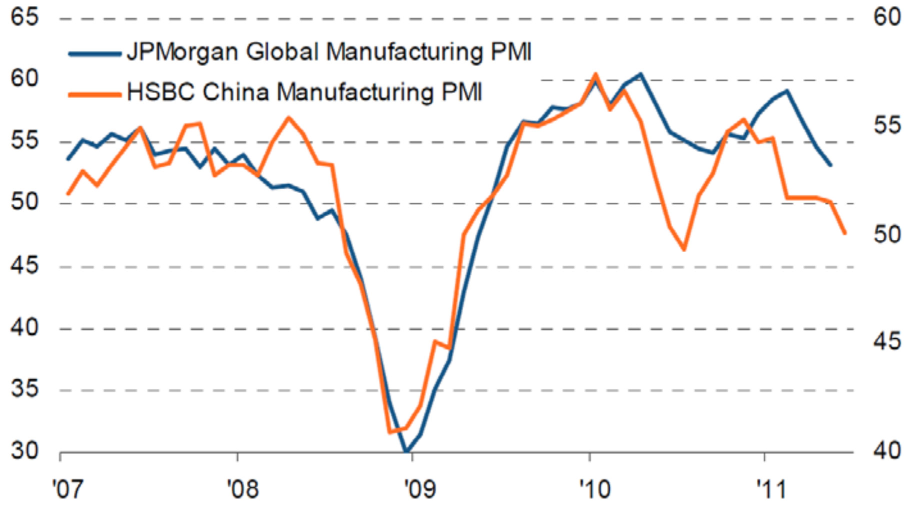
- Create a world leading 'future city' through future-orientated technologies, schemes and services
- A comprehensive package of policies measures, including regulations, tax incentives, focus of budgetary support for key technologies
- Spread the initiative throughout Asia.

Forest and forestry revitalization plan:

- Raise the timber self-sufficiency to 50% and therefore help to revitalise the localised economies
- Promote sustainable forestry practices

Bolstered government support for manufacturing combined with an improving global economic outlook appears to have had a positive impact on the sector. In the US, UK and the Euro area, private sector confidence in the manufacturing sector collapsed during 2008 but returned to pre-crisis levels by early 2010. However, the middle of 2011 was marked by a slowdown in the expansion of Chinese manufacturing (see Figure 1-2).

Figure 1-2: The recovery of global and Chinese manufacturing



Source: Markit, 2011

Emerging economies have maintained and accelerated support for manufacturing during the global economic downturn. Brazil's development bank BNDES financed 40% of investment in infrastructure and manufacturing in the country in 2009[14]. South Africa launched a revised Industrial Policy Framework Action Plan in February 2010. China has many initiatives to support manufacturing, from support for R&D to training of engineers. China's foreign investment has also increased from US$9.11 billion in 2005 to US$63.87 billion in 2009, mostly in energy, metals, and chemicals as well as transportation and communications – the key inputs into the manufacturing processes.[15] National and regional governments also supported the development of special economic zones or industrial parks, in China, Korea and beyond.

The World Bank also shifted its position away from non-interventionist Washington Consensus principals, noting that while industrial policy has often failed, "the historical record also indicates that in all successful economies, the state has always played an important role in facilitating structural change and helping the private sector sustain it across time"[16]. infrastructure, private investment and job creation, human resource development, trade, financial inclusion, growth with resilience, food security, domestic resource mobilization and knowledge sharing. Creating optimal conditions for strong, sustainable and resilient economic growth in developing countries will require reform and transformation across each of these interlinked and mutually reinforcing key pillars.

A study by Deloitte and the US Council on Competitiveness pointed to what it described as a 'new world order for manufacturing competitiveness' in less than a decade, along with a tectonic shift in regional manufacturing competence. Deloitte's Global Manufacturing Competitiveness Index (GMCI) highlights the rise in the manufacturing competitiveness of three countries in particular—China, India, and the Republic of Korea — which appears to parallel the rapidly growing Asian market.[17] According to the GMCI, US, Japan and Germany, the dominant manufacturing superpowers of yore, are now lagging behind these three.

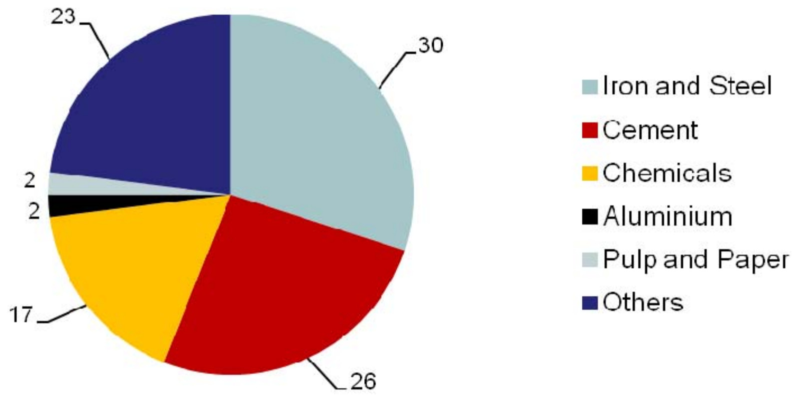
1.2 Industry and the global low carbon economy

The carbon footprint of a country's Industrialization, and its long-term energy and environmental destiny, depends on four tightly linked factors: The resource-intensity of urbanization, the energy-intensity of urban life, and the carbon-intensity of energy production and the nature and pace of economic growth.

This was brought home in China in recent years thanks to a surge in investment in infrastructure and the heavy industry that supplies it. Between 1980 and 2000, China did a remarkable job of growing an economy while restraining energy consumption, as the economy expanded six-fold while the country's energy needs grew at less than half that rate. However, starting in 2001 that trend reversed, and China moved in a much more resource-intensive direction. Over the past six years, energy demand has grown at an average annual rate of 11%, faster than growth in the economy overall.

At the global level, industrial and manufacturing activities together account for over 35% of CO2 emissions (not including the energy sector). The large primary material industries, i.e., chemical, petrochemicals, iron and steel, cement, paper and pulp, and other minerals and metals, account for more than two-thirds of this amount. The top three emitting sectors in China (steel, cement and petrochemicals) have been interlinked with China's industrial development strategy.

Figure 1-3: Contribution of Global Industrial CO2 Production by Industry



Source: IEA, 2009[18]

There are many serious dilemmas and questions. First, how to de-link growth strategies for emerging economies from heavy Industrialization? There seems to be a correlation between growth and investment in heavy industries for countries at early stages of development – shipbuilding; steel making; metals processing; cement. Is this true? Second, how much of emissions-heavy production is due to outsourcing from developed countries? Or are they re-located to developing countries because the trend is to move production closer to sources of materials and/or markets? Third, are the material needs for developing countries – infrastructure, building, transport systems – dictating the future demand for emission-intensive production patterns?

The current economic crisis provides an opportunity for both China and other countries to find a new model for Industrialization. Awash with liquidity over the past several years, there has been less incentive for urban planners and project developers to take a thoughtful approach to resource use when designing and building cities. This created a surge in demand for energy-intensive goods that was met by the most readily available source, regardless of environmental impact. And the energy required to produce those goods was growing so quickly that China was forced to rely on the most proven and accessible sources of supply; coal and coal-fired electricity.

The Chinese government has recognized that to return to a more sustainable model of economic growth, and going further to make that growth low-carbon, China will need to find a new approach to both urbanization and Industrialization. This means:

1. *Changing the way urbanization is planned and funded.* Over the past decade, rapid capital accumulation has allowed for rapid construction of new highways, bridges and buildings. This growth in infrastructure, housing stock and office space has enabled millions of Chinese citizens to seek economic opportunity in the cities, but the way in which this urbanization has occurred creates near-term energy challenges and limits the ability of the country to manage its energy future. Three decades of rapid economic growth has boosted income to Chinese households. Much of this income has been saved, providing state-owned companies and local governments with a relatively unlimited supply of capital to build-out new cities. As is painfully evident today in the West, excess liquidity makes for more resource-intensive construction than would otherwise occur. Officials will need both smart urban planning and smart financial management.
2. *Changing the mix of what China makes for itself and what it buys from abroad.* Good planning and a healthy capital system can reduce the amount of steel, cement, glass and aluminum required for China's urbanization, but beyond that, achieving low-carbon growth will mean buying those materials from the least carbon-intensive producers. Rich in labour and relatively poor in natural resources, heavy industry doesn't play to China's strengths, and it falls short in delivering the types of employment gains the country requires. The five most energy-intensive industries in China consume nearly half of the country's energy resources, but only employ 14 million people out of a labour force of 800 million. Buying these basic materials from other countries with a less carbon-intensive energy mix would both free up resources in China for more labour-intensive activities and help the world meet China's development needs in a more environmentally friendly manner.
3. *Lower the carbon-intensity of energy supply and increase the efficiency of energy use.* While rebalancing Chinese growth away from heavy industry towards light industry and services will no doubt help China find a more sustainable development pathway, low-carbon growth will still require a reduction of the carbon-intensity of the energy system. This means switching to lower-carbon sources of supply and improving the efficiency with which energy is consumed. China has already made important steps in this area and, as a newly emerging economy, has access to low-carbon alternatives that were not available when the West went through its Industrialization.

Delivering on energy efficiency in particular will have a significant impact on Chinese and global emissions. As can be seen in Table 1-1below, large scale savings, can be achieved by improving practices and technology, below for specific sector examples.

Table 1-1: Energy and CO2 Savings Potentials

	World Saving Potential (EJ/yr)	*Chinese Saving Potential (EJ/yr)*	*World Average saving potential (GJ/T)*	*Chinese Average saving potential (GJ/T)*	*World CO_2 Saving Potential (Mt CO_2/yr)*
Chemicals and Petrochemicals	*5.2*	*0.7*	*N/A*	*N/A*	*300*
Iron and Steel	*4.7*	*2.5*	*4.1*	*6.2*	*350*
Cement	*2.5*	*1.1*	*1.0*	*0.9*	*450*
Pulp and Paper	*1.4*	*0.1*	*2.5*	*0.9*	*80*
Aluminum	*0.4*	*0.12*	*N/A*	*N/A*	*45*

Source: IEA 2009[19]

Fuel switching has usually entailed a shift from relatively low-energy-density fuels (e.g. wood, coal) to higher-energy-density ones (e.g. oil), and was driven primarily by technological developments, not income growth (although cause and effect are difficult to disentangle, and changes in the pattern of demand for goods and services may also have played a role).

Energy innovations and diffusion has been driven largely by inherent advantages in terms of costs, convenience and suitability for powering new products (with some local environmental concerns, such as smog in London or Los Angeles, occasionally playing a part). Given the current state of knowledge, alternative technologies do not appear, on balance, to have the inherent advantages over fossil-fuel technologies (e.g. in costs, energy density or suitability for use in transport) necessary for decarbonisation to be brought about purely by private commercial decisions. Strong policy will therefore be needed to provide the necessary incentives.

Technical progress in the energy sector and increased energy efficiency are also likely to moderate emissions growth. One study has found that innovations embodied in information technology and electrical equipment capital stocks have played a key part in reducing energy intensity over the long term. However, in the absence of appropriate policy, incremental improvements in efficiency alone will not overwhelm the income effect.

1.2.1 The role of industrial policy in the OECD

The strength and type of industrial policies deployed in the OECD has varied considerably across different countries and timescales, shaped by factors such as the extent of liberalisation and privatisation, local resource endowment, economic structure, the political influence of industrial sectors and the nature of the particular sector or industry seeking support. Some countries, such as the UK, pursued a relatively non-interventionist approach in the two decades prior to the financial crisis, while others such as Germany and France have always maintained greater state involvement in industry.

In recent decades the governments of Japan, Korea and France have not only supported priority industries but also extensively used measures to support domestic firms with regards to R&D expenditure, access to skills, international trade and access to finance. Compared to other developed countries the state played a particularly important role in these three cases. Korea followed a centralized approach with publicly funded large-scale R&D projects in key areas; government owned research institutes as well as the establishment of large SOEs and direct control of the banking sector to ensure access to finance. Japan put a stronger emphasize on general R&D incentives such as loans, subsidies, tax incentives and the creation of regional R&D clusters. They also involved the private sector in the policy making process regarding the support of priority industries and secured access to finance with more moderate measures than Korea, e.g. the establishment of special banks for long-term industrial financing. France started with a very centralized top-down support of R&D, the funding of selected grand projects and the establishment of SOEs but subsequently moved the focus to bottom-up research grant schemes and cluster support programs.

With respect to access to skills, Japan and Korea put a stronger emphasize on technology imports, while French efforts focused on the local generation of knowledge as well as domestic technology dissemination, for instance by fostering cooperation between companies, research centres and universities. Nevertheless, as far as measures regarding international trade and investment are concerned, all three countries restricted imports to varying degrees and supported their export industries either with subsidies, tax incentives or preferential tariffs.

Contrary to these cases, Germany and the UK did not put a special emphasize on trade and investment measures. Although both countries used instruments from the other four areas, a distinction can still be made with regards to the support of priority industries and access to skills and finance. Especially the set-up of specialized industry associations and chambers of commerce and industry in Germany indicates a stronger commitment to the targeted support of key sectors. The UK government pursued a more limited approach, including occasional investment into priority sectors and loan guarantees but not the establishment of specific institutions. With regards to the improvement of access to skills and capital Germany was also more active. Especially the public vocational training system, including its comprehensive system of training standards, as well as the active support of public savings and cooperative banks to ensure the banking system’s capacity to supply long-term finance stand out here. By contrast, the UK’s industrial policy in these areas is characterized by ‘softer’ measures with a focus on grants and advisory services respectively.

US industrial policy was certainly even less selective with regard to R&D expenditure and access to skills and capital. Most of the measures were based on incentives (e.g. R&D tax credits, competitive university funding and investment capital initiatives) and targeting was only pursued to support SMEs in general, not specific sectors (e.g. technology transfer, sponsored research, technical assistance and credit guarantees). Indeed, SME support is a measure that draws the distinction between Japan, Korea and France that actively supported mostly large-scale industrial endeavours on the one hand, and Germany, UK and the USA who particularly supported SMEs, on the other hand. However, what stands out in particular is the fact that the US government did not put any special emphasize on the support of priority industries, but mostly concentrated on trade policies. Supporting local SMEs with regards to export financing, global marketing and the integration into global value chains was accompanied by promoting free trade initiatives within WTO and through bilateral agreements. In addition, anti-dumping duties, import quotas and foreign ownership restrictions further supported the development of local firms in selected industries. This suggests that cushioning from international competition dominated the US government’s concern for domestic firms.

Table 1-2: Industrial policies in developed countries

Measures	Japan	Korea	France	Germany	UK	USA
R & D expenditure	• R&D loans and subsidies • Special R&D cost deductions • Tax incentives • Large-scale research contracts • Public research organizations & national R&D projects • Promotion of basic research in priority areas • Creation of regional R&D clusters	• National R&D projects • Government-Funded Research Institutes & science parks • Technology Diffusion Institutes • R&D tax credits • Public investment in basic research	• Public R&D financing in key sectors • Bottom-up driven grants by national research agency • Long-term industrial technology programmes • Research tax credit scheme • R&D subsidies	• Large projects on key technologies first • Public institutes between basic and industrial R&D • Steering of co-funded research • Financial R&D incentives for SMEs • Support programmes for specific kinds of innovations • Support of industry-public research cooperation	• Provision of funds for private R&D activities • Fixed minimum budget quota for commissioning of SME related research • R&D tax credits • Innovation management advisory to companies • Collaborative R&D projects	• R&D tax credit for companies • SME technology transfer and R&D funding • Funding of R&D by government agencies & universities • Programs to create networks between firms and research institutions • Sponsored research projects for SMEs
Access to skills	• Technology imports • Royalties for techn. licensing • Bargaining with foreign technology suppliers • Hiring foreign technical advisors • Enhancement of industry-university collaboration • Diffusion of R&D outcomes	• Promotion of technology imports • Creation of demand-oriented technology development system • Extensive technical training • Development and acquisition of top-level scientists & engineers	• Dedicated support of high-tech skills for SMEs • Fostering companies, research centres & universities cooperation • Support of assimilation and dissemination of high technologies • Employment aid schemes	• Set-up of prof. associations • Technology transfer & advisory services • Public vocational training system • Apprenticeship training standards • Easing the access of highly qualified migrants • Short-term work subsidies	• Government funded advisory • Knowledge transfer, training, recruitment & development of skilled personnel • Promotion of manufacturing in schools • Support of business-academia partnerships • Support of apprenticeships	• Competitive process for university funding • Technical support to upgrade technological efficiency • Technical assistance for SMEs • Support of SME manufacturing/business expertise • Technical education grants
International exposure	• Import controls • Inward FDI controls • Foreign exchange controls • Export subsidies • Tariff rebate on imports	• Export targets & penalties • Export promotion • Exemption from import duties • Tax incentives • Trade protection • Non-pecuniary awards	• Export support • Prevention of foreign entries • Import rationing and licenses • Preferential tariffs			• Export financing, global marketing support for SMEs • Bilateral & WTO free trade initiatives • Anti-dumping & countervailing duties • Import quotas • Tax credit for exporters • Foreign owner restrictions
Access to finance	• Off-budget finance • Special banks for long-term industrial financing • Direct subsidies • Subsidized credit • Special depreciation provisions • Etc.	• Direct credit rationing by government • Institutions for large-scale project financing • Instruction of private banks • Preferential access for exporters • Special depreciation allowances • Etc.	• Subsidized loans • Loan guarantees for SMEs • Financial incentives for entrepreneurs • Support of equity financing by SMEs	• Low interest loans and loan guarantees for restructuring of eastern Germany • Active support of banking system's capacity to supply long-term finance • Support of public savings and cooperative banks for SME lending • Financial incentives for entrepreneurs	• Selective investment grant schemes	• Investment capital initiatives • Tax credits for business angels • Loans & credit guarantees for SMEs
Support to priority industries	• Tax preferences • Focused tariff protection • Government subsidies • Partial tolerance of cartels • Deliberation councils for policy making in key sectors • Informal administrative guidance	• Establishment of SOEs & firm nationalisation • Extensive tax incentives • Bail-out guarantees • Reduced electricity and transport prices • Etc.	• Extensive support of grand projects (oil, power, telecom, transport, etc.) • SOEs in key sectors • Dedicated cluster support • Sectoral aid schemes • Reduced VAT rates	• Set-up of industry associations & chambers of commerce and industry • Funding of cluster programmes • Targeted support of environmentally friendly technologies • Sectoral aid schemes	• Occasional investment into priority sectors (e.g. electric cars and civil aerospace) • Limited loan guarantees	

Source: UNIDO, 2011

1.2.2 Reducing Resource Dependency

The movement towards a more resource efficient economy is now as strong as the development of a low carbon economy. This is as result of the increased concern over the impact of higher and fluctuating resource prices on individual sectors and the wider economy. However, it is not a case of either a low carbon economy or a resource efficient economy, and their respective development need to go hand in hand.

In the EU in January 2011 the European Commission published a so-called Flagship initiative on the creation of a resource efficient EU. This has included a timetable of new initiatives in this area (which is included as an annex) and activities under three main pillars.

Fair and sustainable supply of raw materials from international markets: Through action on proposed trade disciplines on export restrictions in bilateral and multilateral negotiations, tackle trade barriers through dialogue but also other tools including WTO dispute settlements and market access partnerships and finally to raise awareness and support awareness-raising in international fora. This is following on from 2008 Raw Materials Initiative[20].

Fostering sustainable supply within the EU: This will encourage the greater use of resources that exist within the EU through the establishment of established an ad-hoc expert group on the exchange of best practices in the area of land use planning and administrative conditions for exploration and extraction; efforts to improve the EU's knowledge database of mineral deposits through better networking of national geological surveys and making optimal use of the satellite-based information system; and EU will continue to promote research projects that focus on the extraction and processing of raw materials.

Boosting resource efficiency and promoting recycling: The European Commission published a Raw Materials Initiative strategy document aimed at improving how recycling markets work through the possible development of best practices in collection and treatment of waste, improvement in the availability of certain statistics on waste and materials flows, and support for research on economic incentives for recycling[21].

Within the EU rules are in place which to increase the recovery and reuse/recycling targets for vehicles which will rise to 95% and 85%, respectively, by 2015, which means the amount of waste being disposed of in landfill would fall from the current figure of about 25% to less than 5%[22]. Such a target is unlikely to be difficult to meet, with, for example, Volvo claiming that it had already reached this target in 2002. Similarly targets have been set for the electrical industry through the Waste Electrical and Electronic Equipment directives. Under these EU laws collection targets equal to 65% of the average weight of electrical and electronic equipment placed on the market over the two previous years in each Member State[23]. These directives have lead to changing practises in industries, both in relation to the recyclability and reuse of components, but also in the level of recycled goods that are included in their products. For example HP has developed an HP Scanjet scanner component made from 25 percent recycled inkjet cartridge plastic and 75 percent recycled plastic bottles, while it has also reduced the different types of plastic used in its equipment[24].

The transition to a low carbon economy will require large volumes of (potentially new) resources in the medium term, as is described in section 2. Resource efficiency and recycling will be critical to reducing exposure to volatile resource prices for materials including iron and steel, lithium and rare earth elements. Over time, countries can also reduce the impact of high resource prices by diversifying economies into higher value added, less resource intensive goods.

Yet to ensure competitiveness, countries and companies are looking to increase the flexibility of manufacturing. This makes the possibility of substitution a priority for innovation. In the medium term these areas of innovation also offer the potential to decouple economic growth from resource consumption, making Industrialization more sustainable. For example, there is much discussion of whether the magnets in large wind turbines can be produced without rare earth elements[25]; can buildings be constructed with smaller amounts of steel; and if resources apart from lithium carbonate can be used in the mass production of electric vehicle batteries; and whether plant can replace oil products as the feedstock for petrochemicals and plastics. Biofuels are another example of substituting one resource input from another, although to date Brazil is the only major economy to have decisively reduced its dependence on fossil fuels in the transport sector.

China’s “new materials” pillar industry is of central importance to its wider low carbon Industrialization. The potential of nanotechnology to greatly enhance the novel properties of certain critical minerals or even open up entirely new avenues for alternative product designs is a key question at present. For example, nano-sized rare earth compounds are already being considered in green technologies such as magnets, batteries, fuel cells, H2-storage and catalysts.

Scientists at National Institute of Advanced Industrial Science and Technology (AIST), Japan, have developed an advanced composite material partly consisting of multi-walled carbon nanotubes which when used in dye-sensitised solar cells, exhibits photoelectric conversion efficiency as high as that of the conventionally used platinum.[26] The United States Department of Energy national laboratory sees nano-structured permanent magnets as a key strategy to lowering the rare-earth content in the permanent magnets [27].

The recent concern over access to rare earth elements highlights the importance of perceived scarcity as a driver for innovation. Increasing awareness over the need for REMs has already triggered rapid supply responses: from the re-birth of the metals recycling in Kosaka, Japan to new plans to reopen or establish new rare earth mines in South Africa, Australia, Canada, the United States, Vietnam, etc.[28] Rare earths are used in permanent motors of hybrid electric vehicles and electric vehicles. Already commercially available alternatives include a number of asynchronous motor designs but ongoing research hints at alternatives to pure Neodymium permanent motors. Most low carbon energy efficient lighting systems contain rare earths. There is now a focus on innovative technologies that can dramatically reduce or eliminate the rare earth content in phosphors used for light emitting diode (LED) and compact florescent (CFL) lighting solutions.

The introduction of novel information and communications technologies (ICT) and systems has the potential to reduce the overall material demands in society. These technologies are already improving the design and operation of industries to make them more efficient. For example, wind power is heavily dependent on ICT technology for site selection, wind farm optimisation, prediction of availability, error detection and security. Factories also use supervisory control and data acquisition (SCADA) systems to optimise their manufacturing processes to track energy and other resource use along supplies chains.

More broadly, ICT are challenging existing technology systems by reducing the need for travel (via videoconferencing and online working environments), accelerating innovation via collaborative approaches, and by bringing producers into a dynamic relationship with consumers. As the sector grows, there are also significant savings to be made by greening ICT systems themselves – the efficiency of servers, low carbon cooling systems and via system level changes (for example, the expected shift to cloud computing).

The full potential and impact of virtualisation and ICT more generally will become clear over time – this is a rapidly evolving field. What is clear is that it has the potential to drive rapid transformation in many areas of society and the economy. ICT plays two key roles in the shift from heavy industry to services; one is slowing the growth in demand for additional roads and buildings through smarter cities and logistics which use these resources more efficiently, and through dematerialization. The other role is in enabling the growth of knowledge intensive service industries that rely on education, information and connectivity.[29] A number of recent international studies have made efforts to quantify the potential offered through ICTs. The SMART 2020 report estimates there is a potential 7.8 GtCO2 equivalent of ICT-enabled abatements out of the total BAU emissions in 2020 (51.9 GtCO2 equivalent).[30]

WWF and China Mobile have published a study focused on China.[31] Focusing largely on transport substitution and dematerialization impacts the study estimates a total of 0.6 GT could be saved by 2020 in this way. The study was based on a detailed examination of the CO2 savings associated with 14 dematerialization services already offered by China mobile in Chongqing, as well as a less detailed assessment of the potential savings from a larger group of applications. The bottom line concludes that, with the right policies there is the potential to reduce emissions by 615 million tons in 2020 and by 1298 million tons in 2030.

1.2.3 Knowledge assets

The low carbon economy will require systemic change across the whole of society, more than just transformation of particular sectors. Innovation at the system level will depend on leveraging the knowledge assets held across the economy and on cooperation along supply chains and across national and sectoral borders. As part of an integrated vision, every pillar industry will play a key role in driving this wider transition. This includes the traditional heavy industries as well as the more disruptive new pillars such as renewable energy, electric vehicles and information and communications technology. Box 1-2 and **Figure 1-4** describe how one example of China's emerging pillar industries, electric vehicles, is highly interconnected with a range of other sectors and technologies including the energy system, materials sciences and energy efficiency. It also demonstrates the extent to which the 8 emerging pillars identified in the 12th Five Year Plan are interdependent with each other's development. Failure to move toward in any one sector will potential have a detrimental impact on a much wider group of technologies, either through reducing the technology specifications and/or creating supply chain bottle necks.

Box 1-2: Electric Vehicles – links with other emerging industries

Manufacturing of electric vehicles will require the development of a variety of technologies from across the traditional and new pillar industries.
New and renewable energy source: The wider use of lower carbon electricity sources will lower the average emissions per km. Without such measures net emissions from the transport sector will not decrease.

New Materials: Technology and performance gaps still exist when comparing EVs to ICE and therefore new products need to be developed, in particular as they relate to electricity storage. These developments will have a wide variety of other uses, e.g. mobile telephones, computers etc

High end equipment: More resilient and often smaller components will improve the efficiency and durability of EVs. The development of these processes and supply chain will have benefits for a wide variety of other sectors and in non-EV transport systems.

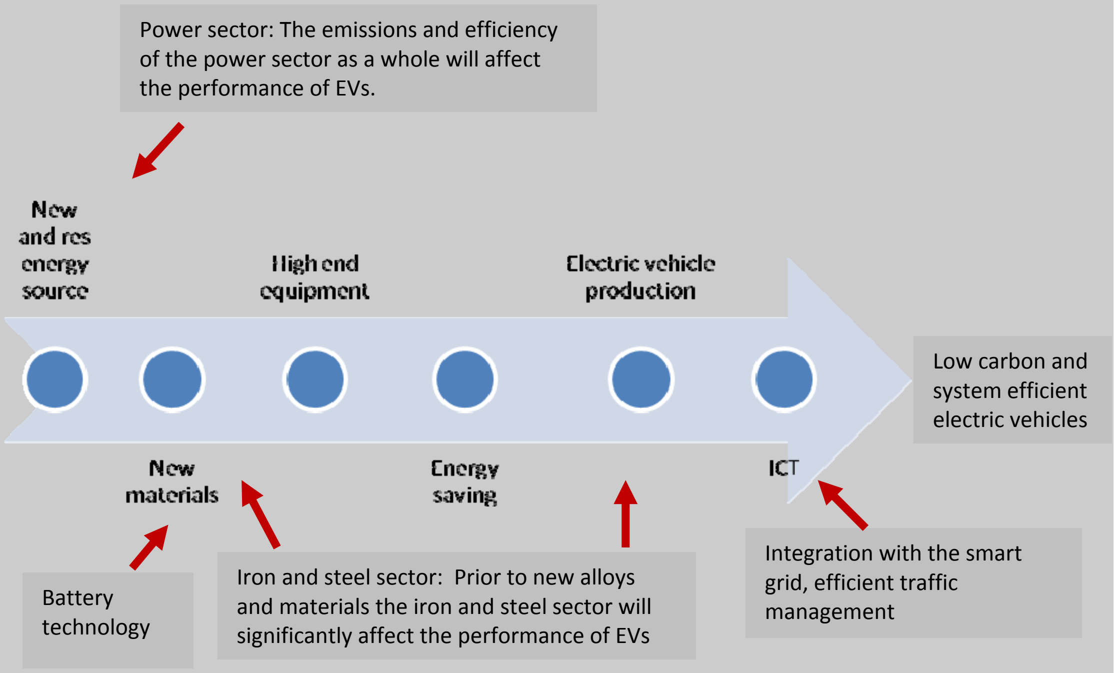
Energy Efficiency: Lower energy using equipment, higher conversion factors, lower weight materials etc are all necessary for the wide utilisation of EVs. These technologies will be deployable in ICEs and other electrical appliances/transport modes (train, bikes etc)

EV production: Creating efficient and functioning supply chains and manufacturing processes will have benefits for other electric appliances and non-EV transport systems.

ICT: A large scale fully functioning EV system will require the roll out of charging systems which will require the integration of ICT. Large scale penetration EV systems envisage the utilisation of the storage capabilities of the vehicles for grid balancing (especially with systems with high renewable penetration) which will not function without integrating the EV and utility systems.

The traditional pillar sectors will also be engaged in the production of EVs and their associated infrastructure, in particular the power sector, iron and steel industries and the traditional automobile companies.

Figure 1-4: The integration of electric vehicles with other emerging pillar industries



Just as important are the links between traditional heavy industries and these new low carbon pillars. Until recently, it was energy intensive heavy industries that were seen as the bedrock of growth and development. They have often been the first port of call for countries bent on climbing the value addition ladder. China is the recent case where heavy Industrialization effectively powered the export-led growth since 2002. In more advanced economies, citizens increasingly question the environmental legacy and the movement of these industries to emerging economies. This has resulted in bifurcation between developed and developing economies as regards the role of the heavy industrial sectors. The reality is that heavy industries are often the most potent industrial assets for many developing countries. In industrial regions they tend to dominate the economic landscape. These industries are so integrated into local economy and society that they are unlikely to be displaced soon, even with the expected explosive growth in low carbon industries.

The key question is how to utilise the assets held by high carbon industries in progress towards low carbon development. Existing technological assets will determine the short term options for low carbon development in a given area and heavy industries in industrialising countries tend to be among the strongest in terms of knowledge assets.

This makes heavy industry an important potential catalyst for driving low carbon Industrialization, even though energy intensive companies may have short term interests in maintaining the status quo. The evidence for this is clear in China's efforts to propel BYD from a battery manufacturer to an electric car pioneer, and in industrial giant Tata's pivotal role in wind and electric vehicles in India. There are examples from developed countries too - electronics firm Nokia has its roots in the paper and pulp and cable manufacturing industries.

The knowledge assets held by heavy industry give them a particular importance in accelerating local technology innovation in industrialising countries. For example, local university research capacity is often geared to support these historically important industries and will work closely with the companies themselves. Large industrial enterprises also have major advantages in distribution networks and logistics capacity, particularly in the transport and retail of fossil fuels. These assets will, for example, play a key role in deploying biofuels and perhaps hydrogen in future. The power sector will play a key role in providing the infrastructure for electric vehicle charging. Heavy industries are also some of the largest companies in developing countries. This gives them access to finance and longer term investment options. While they are not always known for risk-taking, they do have the capacity to invest in large-scale pilots focused on capitalising on the linkages with low carbon growth opportunities.

Heavy industries are interconnected with many parts of the economy since they provide the fundamental materials used in the production of many products. This is particularly the case for intermediate products such as steel and petrochemicals. The quality and type of these products produced by heavy industry will be critical in the decarbonisation of all sectors, enabling lightweight materials and advanced applications.

1.3 International experience of low carbon Industrialization policies

Today, many ambitious policies and measures have been put forward to support low carbon transition from governments around the world. In many countries domestic emissions targets set the framework for low carbon transition. The array of policies and measures in the EU, for example, is focused on meeting the EU's proposed 2020 target of either a 20% or 30% cut depending on action by other major economies.

While long term targets set the overall context, midterm targets are used to drive short term action. For example, the South African government has announced that its GHG emissions will stop growing at the latest by 2020-2025, stabilise for up to ten years and then decline in absolute terms.[32]

This section reviews international experience of some of the key policy areas for low carbon Industrialization, including fiscal tools, market based instruments and technical standards.

1.3.1 Energy pricing, subsidies and carbon taxation

The IEA estimates that fossil-fuel-related consumption subsidies amounted to US$ 557 billion in 2008. Based on its analysis, if these subsidies were phased out by 2020 it would result in a reduction in primary energy demand at the global level of 5.8% and a fall in energy-related carbon-dioxide emissions of 6.9%, compared with a baseline in which subsidy rates remain unchanged. Furthermore, subsidies provided to producers of fossil fuels may be on the order of US$ 100 billion per year. The total order of magnitude of subsidies to consumers and producers – almost US$ 700 billion a year - is roughly equivalent to 1% of world GDP. In parallel, OECD countries have been raising taxes on energy, mainly fossil transport fuels, in amounts exceeding US$ 400 billion in each of the years between 2003 and 2008; these taxes significantly affect relative end-use prices for fuels. Subsidies to other non-fossil-fuel energy are considerable and have been increasing over time. A rough estimate by the Global Subsidies Initiative (GSI) indicates around US$ 100 billion per year are spent to subsidize alternatives to fossil fuels.[33]

At the G20 meeting in Pittsburgh in September 2009, Leaders agreed to phase out and rationalize over the medium term inefficient fossil fuel subsidies while providing targeted support for the poorest, noting that 'inefficient fossil fuel subsidies encourage wasteful consumption, reduce our energy security, impede investment in low carbon energy sources and undermine efforts to deal with the threat of climate change'.[34] To deliver on their commitment in Pittsburgh, G20 countries have developed strategies and timeframes for implementing national-level policies to rationalize and phase out inefficient fossil fuel subsidies. Among the measures proposed for phase out by some countries are included such measures as preferential tax incentives for oil production, financial support for domestic coal industries, and direct subsidies for general fuel consumption. However Achim Steiner, head of the United Nations Environment Program, told Reuters in 2011 that despite some progress, countries were not moving fast enough and there is no collective implementation.[35]

Table 1-3: Country strategies for removal of energy subsidies

Country	**Summary of Implementation Strategy**
Argentina	Proposes to reduce household subsidy for propane gas consumption as natural gas access is expanded.
Australia	No inefficient fossil fuel subsidies.
Brazil	No inefficient fossil fuel subsidies. Lists several government measures in the energy sector related to the production or consumption of fossil fuels
Canada	Proposes to implement recently released draft legislation to phase out the accelerated capital cost allowance for oil sands assets over the 2011-15 period. Previously phased out other tax incentives applying to fossil fuel producers.
China	Proposes to gradually reduce the urban land use tax relief for fossil fuel producers.
France	No inefficient fossil fuel subsidies. Previously reformed subsidies for hard coal mining.
Germany	Proposes to discontinue subsidized coal mining in a socially acceptable manner by the end of 2018.
India	Proposes to work out implementation strategies and timetables for rationalizing and phasing out inefficient fossil fuel subsidies based on the recommendation of the Empowered Group of Ministers that has been constituted.
Indonesia	Proposes to phase out inefficient fossil fuel subsidies in a gradual manner in parallel through managing the demand side by adopting measures that will reduce fossil fuel energy consumption and by gradually narrowing the gap between domestic and international prices.
Italy	Proposes to continue with planned expiration of subsidy for certain cogeneration plants, and negotiate on a voluntary basis with private operators of these plants on the timing of their recess from the subsidy scheme.
Japan	No inefficient fossil fuel subsidies.
Korea	Proposes to phase out subsidies to anthracite coal and briquette producers.
Mexico	By continuing current policies and based on current market conditions, subsidies to gasoline, diesel and LP gas are expected to disappear in the medium term.
Russia	Proposes to implement the commitment to rationalize and phase out inefficient fossil fuel subsidies through national economic and energy policy, within the

	framework of its Energy Strategy 2030 and the Concept of Long-Term Social and Economic Development, as well as in the context of its joining the WTO.
Saudi Arabia	No inefficient fossil fuel subsidies. Saudi Arabia has a long-standing energy policy to improve the utilization of economic resources with emphasis on rationalization.
South Africa	No inefficient fossil fuel subsidies. Noting recently introduced electricity tax that applies to electricity generated from non-renewables as well as other relevant tax measures and incentives to reduce wasteful consumption and encourage low carbon energy development.
Spain	Proposes to implement current coal industry restructuring plan until 2012 when further restructuring will be considered.
Turkey	Proposes to work on a restructuring plan to rationalize the inefficient producer subsidies transferred to a stated-owned hard coal producing enterprise.
United Kingdom	No inefficient fossil fuel subsidies. Previously reformed subsidies for hard coal mining.
United States	Proposes to pass legislation to eliminate twelve preferential tax provisions related to the production of coal, oil, and natural gas.

Source: G20, 2010[36]

For decades governments around the world have used energy taxation to generate revenue and encourage efficiency. More recently policies have aimed specifically to encourage a switch to lower carbon fuels. Proposals for carbon taxation in the EU, US, New Zealand, South Africa and parts of Canada have emerged at various times over the last ten years. However it has proven to be a highly contentious political issue and most proposals have been withdrawn.

Several European countries, however, have introduced new carbon taxes as part of a broader trend of environmental tax reform. Norway has had a carbon tax of approximately US$50 per tones of CO2 covering about 60% of national emissions since 1991. While in the EU notable examples are Sweden, Finland, the Netherlands, Denmark, Germany and the United Kingdom. A recent study concluded that the introduction of carbon or energy taxes with revenue recycling in most of these countries had a positive effect on GDP compared with the counterfactual reference case of no environmental tax reform, with a neutral effect in the United Kingdom.[37] Table 1-4 shows the level of carbon taxation in selected countries.

Table 1-4: Carbon Tax Policies

Country/ Jurisdiction	Start Date	Tax Rate ($USD unless noted otherwise)	Annual Revenue	Revenue Distribution
Finland	1990	$30/metric ton CO_2 (€20)	$750 million (€500 million)	Government budget; accompanied by independent cuts in income taxes
Netherlands	1990	~$20/metric ton CO_2 in 1996	$4.819 billion[a] (€3.213 billion)	Reductions in other taxes; Climate mitigation programs
Norway	1991	$15.93 to $61.76/metric ton CO_2 (NOK 89 to NOK 345)	$900 million (1994 estimate)	Government budget
Sweden	1991	Standard rate: $104.83/metric ton CO_2 (910 SEK) Industry rate: ~$23.04/metric ton CO_2 (~200 SEK)	$3.665 billion (25 billion SEK)	Government budget
Denmark	1992	$16.41/metric ton CO_2 (90 DKK)	$905 million	Environmental subsidies and returned to industry
United Kingdom	2001	$0.0078/kWh for electricity; $0.0027/kWh for natural gas provided by gas utility; $0.0175/kg for liquefied petroleum gas or other gaseous hydrocarbons supplied in a liquid state; and $0.0213/kg for solid fuel	$1.191 billion (£714 million)	Reductions in other taxes
Boulder, CO	2007	$12-13 per metric ton CO_2	$846,885	Climate mitigation programs
Quebec	2007	$3.20 per metric ton of CO_2 (C$3.50)	$191 million (C$200 million)	Climate mitigation programs
British Columbia	2008	$9.55 per metric ton of CO_2 in 2008 (C$10), increasing $4.77 (C$5) annually to $28.64 (C$30) in 2012	$292 million (C$306 million)	Reductions in other taxes
BAAQMD, California	2008	$0.045 per metric ton of CO_2e[b]	$1.1 million (expected)	Climate mitigation programs
France	proposed	$24.74 per metric ton of CO_2 (€17)	$4.499 billion (€3 billion) expected	Reductions in other taxes
CARB, California	proposed	$0.155 per metric ton CO_2e in FY 2010-11, dropping to $0.09 per metric ton CO_2e in 2014	$63.1 million 2010-2013; $36.2 million starting in 2014, expected	Climate mitigation programs

[a] Revenue in the Netherlands is from all environmentally related taxes, of which carbon taxes are the clear majority.
[b] CO_2e is carbon dioxide equivalent.

Source: NREL, 2009[38]

1.3.2 Emissions trading

Cap and trade systems play a significant role in international experience of low carbon transition. Two key reasons are that they create a national cap of emissions in key sectors that can be reduced over time and that through trading they set a price for carbon, which has created huge new global markets in low carbon alternatives and made high carbon options less attractive. At the moment the global market is dominated by trading in Europe. Plans to introduce an emissions trading scheme in South Korea, New Zealand, Australia and perhaps South Africa and Japan indicate a global trend. However the major outlier is the United States, where proposals for cap and trade legislation have been repeatedly rejected by Congress. New Carbon Finance suggested that, depending on the design, the value of the carbon market in the US could be in the order of $1 trillion per year by 2020 – but for the time being there is little prospect of a scheme being introduced.

Experience of international emissions trading is by far dominated by the European Emissions Trading Scheme (EUETS). After 5 consecutive years of robust growth, the total value of the global carbon market remained stable in 2010 at about $142 billion. The EU ETS market accounted for 85 percent of global carbon market value. This share rises to 97 percent if the value of the secondary 'Clean Development Mechanism' transactions is also taken into account.[39]

The design of the EU-ETS is somewhat particular to the existing governance structures in Europe, but the scheme also displays several classical features of emissions trading schemes and as the largest and most mature carbon market in the world, it provides very valuable lessons when thinking about the potential for a wider global role of carbon markets. A detailed description is beyond the scope of this paper, and has been summarised elsewhere in the literature to a great extent (see e.g. Ellerman[40]). Nevertheless, because of its importance, some features are worth describing here. The scope of the EU-ETS currently covers annual emissions of around 3000 million tonnes of CO_2 from large stationary combustion sources over 50 $MW_{thermal}$. This includes most of the industrial sector (including refineries), all of the power generation sector, and the offshore energy sector. Each company in the scheme is required to keep sufficient allowances in an electronic registry account to cover every tonne of CO_2 they emit each year. If companies fail to hold sufficient allowances to cover their independently verified annual emissions, they pay a fine of €100/tCO_2, and then have to subsequently cover the shortfall in the subsequent year.

In the first two phases of the scheme, companies were given a large proportion of their required allowances for free. New entrants to the scheme (e.g. new plant build) have also been allocated free allowances, despite the lack of economic justification on the grounds of stranded capital. Companies can sell any surplus allowances, and any shortfall must be purchased from the carbon market. Third party traders and brokers are also allowed to trade, and the market comprises a mixture of over-the-counter trades and carbon exchanges. Considering the high degree of free allocation, liquidity in the first two phases has been relatively good. It should become significantly better in Phase III as the scheme moves towards predominantly auctioning of allowances.

An important feature driving the price of the EU allowances so far has been the rules concerning banking and borrowing of allowances. The scheme does not allow borrowing of allowances from future periods to be used in the current trading period. In the first phase of the scheme (2005-2007), no banking of allowances from this period into the subsequent 2008-2012 period was allowed either. This meant that surplus allowances left over at the end of 2007 were essentially worthless, and the price of carbon dropped to zero. From now on, banking of allowances from one trading period to another is allowed, so that China should not see a repeat of the price collapse that occurred in Phase I as long as there is an expectation of scarcity of allowances in the long-run. Borrowing is still not allowed, so in principle the price spiking at the end of trading periods is still possible. In practice, companies will probably hedge against this risk by abating and/or purchasing more allowances than necessary and banking these surplus allowances to create a safety net.

The day-to-day behaviour of the allowance price in Phase I prior to the price collapse was linked to the marginal cost of switching from existing coal-fired to gas-fired power generation. As the gas-coal price differential increases, the price of carbon required to incentivise this switch also rises and vice versa. In the longer run as the generation mix in the EU finds a new equilibrium factoring in the existence of a carbon price, and taking account of the retirement of significant amounts of coal in Europe as a result of the Large Combustion Plant Directive[41], other abatement options will come into the equation. In early stages of Phase II, prices showed signs of responding to other factors such as expectations of the future cost of CCS[42].

As a mandatory regulatory instrument, the EU-ETS is likely to be very stable. What is less certain is the ambition level of the cap which has perhaps the most important impact on the carbon price. The EU and national governments are caught in the middle of conflicting priorities in this regard. On the one-hand, predictability and transparency in policy-making processes are important to investors, suggesting the need for target setting to be specifically focused on the needs of the EU carbon market (Gross 2007). On the other hand, the same national governments are involved in international negotiations in which political economy and gaming considerations become predominant. In this context the EU (like many other parties to the UNFCCC) set targets that are contingent on the commitments of other parties in order to avoid commitments becoming too far out of line with economic partners. The EU target was for a 20% or a 30% reduction in emissions by 2020 relative to 1990. Whilst this contingency may make sense from the point of view of strategic bargaining within the UNFCCC context, it does not help create stable investment conditions for domestic industry. The EU is currently negotiating an internal target consistent with the UNFCCC pledge.

In 2011, the European Commission produced a roadmap to 2050[43] setting out key milestones and policy actions required to meet long-term goals. This roadmap adds two important things to EU policy. Firstly it begins to resolve the EU's dilemma over 20% vs. 30% emissions reductions target by 2020. Secondly it helps to bridge the gap between the hard regulatory targets for 2020, and the softer aspirational targets for 2050. Both of these are good news for carbon markets, which have been left weakened by a lack of stringent targets. A contingent target for 2020 means that policy becomes hostage to the decisions of others. A 20% reduction doesn't put the EU on a path to its long-term target, whilst the EU's conditions look unlikely to be met for increasing the target to 30% in response to similar targets being taken on by other major economies. The suggested target for 2020 in the roadmap is a 25% reduction in emissions to be achieved domestically within the EU. Adjusting for the use of offsets, this comes quite close to the original 30% emission reduction target for the EU.

Just as significant for carbon markets would be a move towards providing targets for 2030, as suggested in the Commission's roadmap. Carbon prices are determined not by the balance of supply and demand now, but in future periods as well because of the ability to bank allowances for sale in future periods. Again, the roadmap looks to be tightening longer-term expectations. The implied emission reductions for 2030 relative to 2005 under current policy for the EU-ETS is a 30%-48%[44] reduction, whereas the roadmap increases this to 38%-50%. However, the targets for the EU-ETS in 2020 and 2030 have still not been clearly stated.

Tightening the caps will lead to higher carbon prices, but will also help to reduce policy risk in the carbon market according to recent analysis by Chatham House and London Business School[45]. This research shows that when caps are weak, carbon price variations are dominated by policy risks which companies generally find more difficult to manage than market risks. Conversely, with strong caps in place, carbon price risk mainly arises from market-based risks (e.g. fuel price variations), which companies are in a better position to hedge and manage. Another consequence of a tighter 30% cap is that revenues accruing to Member States from auctions of EU-ETS allowances would increase significantly to €42bn compared to €22bn under a 20% in 2020. The revenues would also be a lot more certain under a 30% cap. Under a 20% cap (without the prospect of tighter caps in subsequent periods), there is a significant probability of very low or even zero revenues accruing from allowance auctions due to a collapse in the carbon price. Box 1-3 below sets out EU plans for allocating a share of this revenue to climate change-related investments.

The impact of the emissions cap is obviously crucial to the EU-ETS. By comparison, in macroeconomic terms, the way in which emissions allowances are allocated has very little effect on the overall economic and environmental efficiency of an emissions trading scheme. However, from the point of view of individual companies, the method used to allocate allowances can have a very significant effect on cash-flow. The early stages of the EU-ETS (as with other major emissions trading schemes such as the US SO_2 program) were characterised by a high degree of free allocation to incumbent companies. This represented a significant wealth transfer from the public sector to the private sector, given allowances represent assets worth over €150bn, with ownership transferred companies covered by the scheme. This transfer was justified on the grounds that the operating costs for these companies would be increasing as a result of the additional costs of carbon created by the EU-ETS. However, in many cases the degree of free allocation significantly over-compensated companies. This was particularly the case in the electricity sector, where electricity prices generally increased to cover the additional running costs, such that the carbon price was effectively passed on to the consumer. The value of the free allowances therefore effectively accrued to the power companies as windfall profits. Such effects also occurred but to a lesser extent in other manufacturing sectors.

These issues led to a redesign in the third phase of the EU-ETS, such that there is a progressive move towards almost full auctioning of allowances by the end of Phase III. The power sector will see a particularly rapid move towards full auctioning during the early part of the third phase. This move marks a significant centralisation of allocation of allowances across the EU. In earlier phases, allocation to different sectors was left up to individual Member States, with the role of the EU limited to an oversight function ensuring that individual plans added up to a sufficient level of environmental improvement across the EU as a whole. In Phase III, the total number of allowances to be created is determined for the EU as a whole. These are then divided between Member States who may hold their own individual auctions, and retain the income from these auctions.

Allowances are divided between Member States according to a politically agreed formula, resulting from a negotiating process between Member States. This represents a significantly better defined process than under the earlier phases of the scheme. In phases I and II, Member States also had a politically negotiated agreement defining emissions limits, but these had been negotiated in the context of the Kyoto targets for the period 2008-2012, and covered total emissions of greenhouse gases at the national level. Member States were able to define their own (free) allocations of CO_2 allowances to companies in the EU-ETS, as long as they could show that these allocations were in line with the national greenhouse gas targets. These plans were laid out in so-called National Allocation Plans written by each country. This system was significantly less robust, because the political economy at national level encouraged each Member State to tend towards over-allocation. Although the plans were vetted by the EU, and reductions in allocation levels were consequently made, the system was subject to political pressure to weaken the environmental integrity of the scheme.

This centralisation has made the target setting process more transparent and robust, and has led to better coordination of supply and demand across the trading system. These measures should help remove competitive distortions between Member States since all companies would have equal access to allowances at the same price, and improve the efficiency of the mechanism. Nevertheless, centralising decision-making in relation to any form of taxation in the EU is difficult politically because of the sovereignty of Member States to raise taxes over which the EU does not have jurisdiction. Auction revenues accruing to Member States, could be in the region of €30-60bn per year depending on the carbon price. There is some tension over the use of these auction revenues however: Member States would generally like to maintain the maximum amount of flexibility over how the funds are spent to meet their own domestic political agendas, whereas the EU would prefer ensure that a significant fraction of the revenues are spent on environmental improvements so as to help ensure the environmental effectiveness of EU policy.

The increased transparency in the target-setting process does not however made political agreement any easier on what the target should actually be – as discussed above, there is still ongoing negotiation over what target to set for 2020 within the EU-ETS. Nevertheless, the EU-ETS provides useful lessons for China when thinking about how targets would be set, and allowances allocated. Free allocation of allowances can certainly help to overcome the resistance of companies to a change in regulatory regime in the early stages of introducing the scheme. However, the complexities of determining exactly what level of allowances each company should get soon start to outweigh the benefits, and policy-makers should plan for a relative rapid transition towards auctioning of allowances rather than free allocation. Auctioning has many benefits in terms of ensuring a level playing field for all companies in the trading scheme, and creates much clearer investment signals for companies to help start the process of decarbonisation. Auctioning allowances also avoids the competitive distortions that can arise between sectors and regions from allocation schemes that are based on politically negotiated target-setting processes. A centralised auction mechanism creates a single price for all companies. It also creates the possibility to raise significant amounts of revenue, and agreement on how to spend these revenues needs to be reached (for example, how such revenues should be divided between central and regional governments, and how much should be earmarked for environmental improvements etc.).

Box 1-3: Auction revenues from the EU Emissions Trading Scheme

Auction revenues from the EU-ETS could be in the region of €30-60bn per year by 2020. This is a significant amount; over the period to 2020, the total income could be over €300bn, giving the EU a low-carbon 'war chest' almost an order of magnitude larger than the amount allocated to green energy in the US stimulus package. The Directive has been amended to require Member States to spend at least 50% of these revenues (or an equivalent amount from the central budget) on one or more of the following climate-related areas:

- To reduce greenhouse gas emissions, including by contributing to the Global Energy Efficiency and Renewable Energy Fund and to the Adaptation Fund as operationalised by UNFCCC COP 14 in Poznan , to adapt to the impacts of climate change and to fund research and development as well as demonstration projects for reducing emissions and adaptation , including participation in initiatives within the framework of the European Strategic Energy Technology Plan and the European Technology Platforms;

- To develop renewable energies to meet the commitment of the Community to using 20% renewable energies by 2020, as well as to develop other technologies contributing to the transition to a safe and sustainable low-carbon economy and to help meet the commitment of the Community to increase energy efficiency by 20% by 2020;
- For measures to avoid deforestation and increase afforestation and reforestation in developing countries that have ratified the future international agreement ; to transfer technologies and to facilitate adaptation to the adverse effects of climate change in these countries;
- For forestry sequestration in the EU;
- For the environmentally safe capture and geological storage of carbon dioxide , in particular from solid fossil fuel power stations and a range of industrial sectors and sub-sectors, including in third countries;
- To encourage a shift to low emission and public forms of transport;
- To finance research and development in energy efficiency and clean technologies in the sectors covered by the scope of the directive;
- For measures such as those intended to increase energy efficiency and insulation or to provide financial support in order to address social aspects in lower and middle income households;
- To cover administrative expenses of the management of the Community scheme.

One problem with such earmarking is that the income from both emissions trading schemes and taxes are uncertain. In the case of trading schemes, the quantity of allowances to be auctioned is known but their price is uncertain, whereas in the case of a tax, the price is known but the emissions level is uncertain. Governments will therefore need to identify who bears the risk of these uncertainties when they commit funds to long-term programs such as R&D or adaptation where secure financing will be important.

Another issue that affects the possible design of a Chinese emissions trading scheme is the type of target that would be defined for the participating companies. The EU-ETS sets targets in terms of an absolute level of CO_2 emissions during the compliance period. Other emissions trading schemes may be based on a relative target, which could relate emissions to some measure of activity such as emissions per unit of output. Relative targets may provide more flexibility and be perceived as having lower economic risk for participating companies, as they might appear to be less constraining of economic growth. Clearly, the total amount of effort required by any particular company would depend on the stringency of the targets under either an absolute or relative target system.

There is less experience of full-scale trading schemes using relative targets. One of the complications of such a scheme is that the final allocation of allowances to a company can only take place once the final figure for the company's output during the compliance period is known (although some initial allocation could be made with ex-post adjustments). The risk of expanding the total number of allowances in the system as a result of economic (and hence emissions) growth has led to caution in the use of these mechanisms. One example occurred in the UK emissions trading scheme where one set of participants had absolute CO_2 targets, and another set of participants had intensity-based targets. Trading between the two groups was constrained by a 'gateway' which limited the flow of allowances from the intensity-based group, to ensure that there was no devaluation of the carbon 'currency' in the trading system. The mechanism proved relatively complex to administer, and the UK-ETS was superseded by the EU-ETS.

Nevertheless, designing an emissions trading scheme around intensity-based targets is possible, as long as robust systems can be put in place to measure the output quantity sufficiently accurately to allow calculation of performance against targets (relative to a business as usual pathway – itself challenging to define), and as long as it is recognised that the targets will have to show a steeper decline over time than absolute targets in order to achieve the same environmental effectiveness in a context of economic growth.

Linking an ex-post allocation system to the EU-ETS is in principle possible, as long as there were clear rules regarding the status of allowances in relation to any allowances that were issued prior to final ex-post adjustments). Linking of emissions trading schemes can lead to economic benefits for companies in both schemes, as it encourages investment in the least-cost abatement options in the two regions covered by the linked schemes. The political, economic and environmental benefits of linking depend on the wider policy framework in place governing the accounting of emissions at national level. Linkages between two countries which themselves have absolute targets would appear to be more politically acceptable, since any additional environmental impacts created by faster-than-expected economic growth in the trading scheme would have to be offset by the government (e.g. by achieving greater emission reductions in other sectors outside the trading scheme, or by buying international emissions offsets). However, in practice, it seems unlikely in the near future that the EU would agree to link the EU-ETS to an intensity-based scheme because of the additional complexities and environmental uncertainties involved.

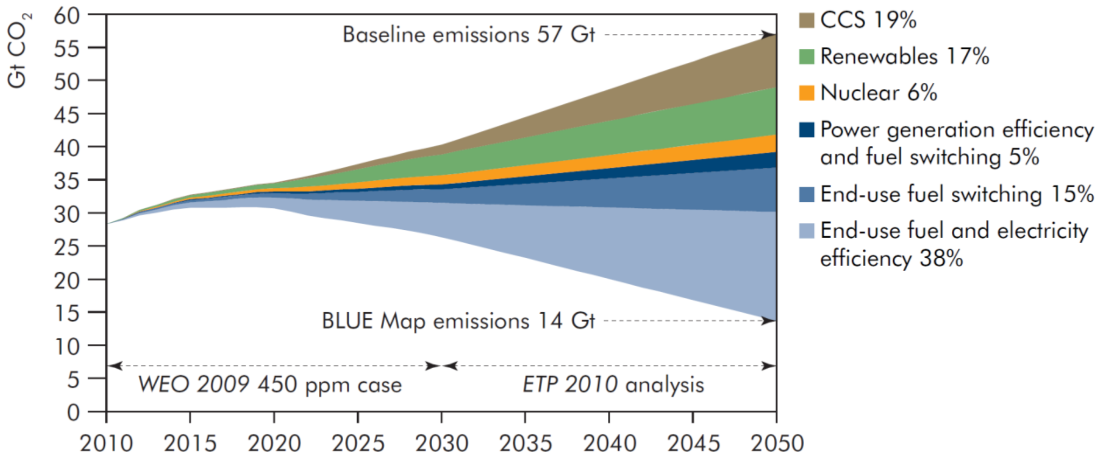
Another interesting aspect of the recent changes to the EU-ETS is the increased coverage of the scheme to include new sectors, most notably the aviation sector. Clearly, aviation is an international business, and unilateral action risks creating competitive disadvantages for EU-based flight routes which could affect European airlines and airports. This competitiveness effect was the reason why an international deal had been sought through the International Civil Aviation Organisation as a parallel to the Kyoto Protocol, but no international solution appeared to be forthcoming. The fact that the EU has managed to agree to bring aviation within the scope of the EU-ETS shows that it is possible for regions that are sufficiently large to take unilateral action in the absence of adequate international measures. It remains to be seen what the actual competitiveness effects will be. It also remains to be seen whether inclusion of aviation in a regional scheme leads to increased pressure from companies to create a level playing field by pushing for a more harmonised international approach to aviation emissions.

1.3.3 Energy efficiency in industry

According to both the IPCC and the IEA, cost-effective energy efficiency improvements could contribute to half the potential emissions reductions by 2020 and beyond. Furthermore, energy efficiency addresses all aspects of energy policy, environmental sustainability, security of supply and competitiveness largely at a lower cost than new supply options.

Figure 1.3 below, from the IEA's Energy Technology Perspectives, illustrates the potential role of energy efficiency in meeting CO2 emissions reduction targets. End-use fuel efficiency and end-use electricity efficiency could provide 38% of the emissions savings by 2050. As the IPCC said in its Fourth Assessment Report, it is often more cost-effective to invest in end-use energy efficiency improvement than in increasing energy supply to satisfy demand for energy services.

Figure 1.3: potential role of energy efficiency in meeting CO2 emissions reduction targets



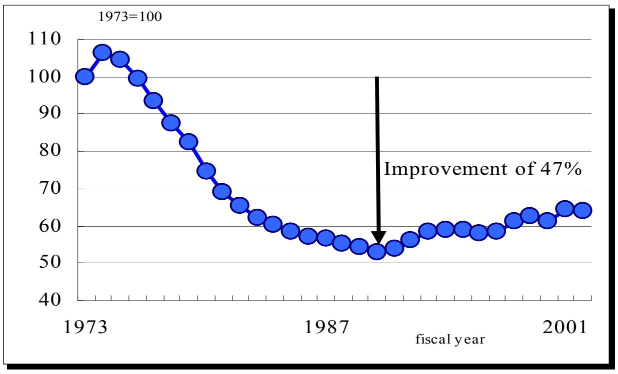
Source: IEA 2010[46]

The EU energy efficiency action plan proposes a 20% improvement in energy efficiency by 2020. This is already resulting in a dramatic increase in attention paid to energy efficiency across the EU. If successful, this would mean the EU would use approximately 13% less energy than today by 2020, saving €100 bn and around 780 millions tonnes of CO2 each year.

A number of EU Member States including Ireland and the UK have proposed bans on the use of inefficient lighting systems, in line with the objectives of countries like Australia and regions like California. Significantly, the European Commission has been asked by the Member States to examine areas where economic instruments, including VAT rates, can have a role to play to increase the use of energy-efficient goods and energy-saving materials.

Due to low resource endowment Japan has always been aware of the importance of security of supply. Concerns were heightened in the 1970s with the oil shock and lead to the introduction of strong domestic programs, which resulted in the Japanese economy become one of the most energy efficient in the world. Figure 1-5 below demonstrates the extent to which these policies were successful in driving down the energy intensity of the country’s economy.

Figure 1-5: Manufacturing industry in Japan: Energy consumption per production

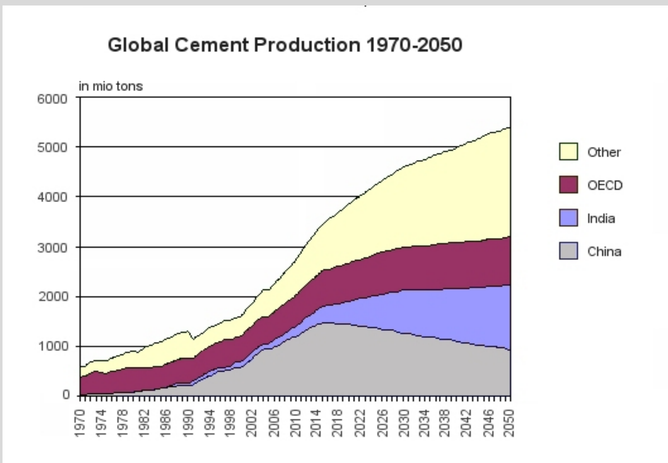


Source: IEEJ-EDMC, Handbook of energy & economic statistics in Japan

In response to energy challenges, Japan addressed energy use across all sectors of society. These policies include setting of standards for boiler, promotion of energy efficient appliances and lighting; and the use of intelligent transport systems. However, in recent years the improvements in energy efficiency have stagnated. To further stimulate improvements, new initiatives being put forward. Specifically, the 'Top Runner' program was developed in 1999 to set targets by product category, for instance cars, TVs, or air conditioners. In each category, the most efficient model currently on the market is used to set the standard to be attained within four to eight years.

By the target year, each manufacturer must ensure that the weighted average of the efficiency of all its products in that particular category is at least equal to that of the top runner model. This approach eliminates the need to ban specific inefficient models from the market. At the same time, manufacturers are made accountable and, perhaps most importantly, they are stimulated to voluntarily develop products with an even higher efficiency than the top runner model.

Box 1-4: The case of cement



Source: International Energy Agency (IEA)

The cement industry contributes about 5% to global CO2 emissions and around 18% of GHG emissions produced by industry. Under a business as usual scenario these emissions are expected to rise from around 2 billion tons today to just under 5 billion tons in 2050[47]. Production is energy intensive, primarily using coal, and energy consumption by the industry is around 2% of global energy consumption, and 5% of industrial consumption.

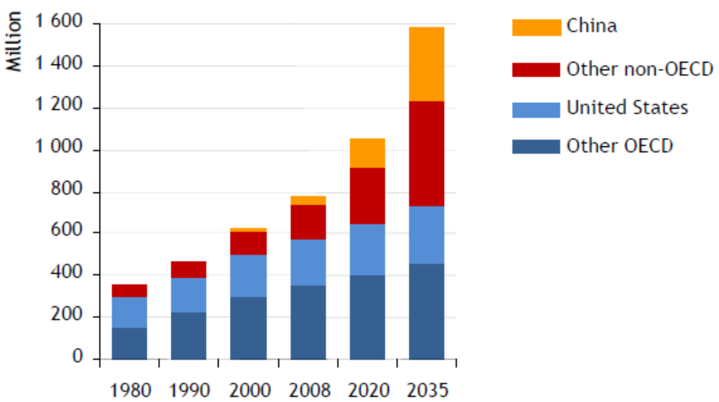
Of the top twelve producers of cement in the world (around 81% of the world total) only three have experienced negative growth since 1999 (EU, Japan and Turkey). The cement industry continues to grow most rapidly in developing countries as it responds to demand for infrastructure and housing; this is especially true for China, India and a number of Middle Eastern countries. Yet some of the cleanest cement plants, are located in these rising economies due to newly built facilities; the older, least efficient plants tend to be in US. Whilst cement emissions in Europe, Australia and Japan are declining or stagnant, they have risen in East and South Asia, as well as South America, the USA and the Middle East.

The WBCSD estimates that 80% of the future emissions from cement plants will take place in emerging economies such as China and India. China accounts for 50% of the global market in terms of both production and consumption of cement (a figure that is widely predicted to rise[48]) which not surprisingly has an important impact on China's energy use and CO2 emissions. Yet the international trade volume of Chinese cement is very limited, suggesting a strong correlation between Chinese growth and high levels of consumption in the cement sector driven by domestic infrastructure needs.

1.3.4 Efficient vehicles

Global automobile demand is set to grow rapidly, largely driven by increasing car ownership in developing countries as incomes rise. In IEA's baseline scenario, the total stock increases from about 750 million in 2007 to more than 2.2 billion by 2050. This represents a major area of potential growth in greenhouse gas emissions.

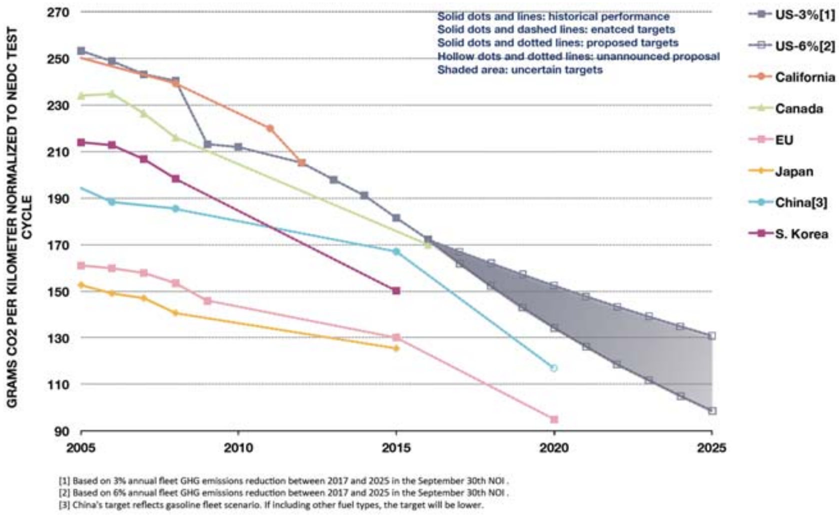
Figure 1-6: Passenger vehicles in the IEA's New Policies Scenario



Source: IEA 2010

The three main options for reducing automobile emissions are to: encourage modal shift to alternative forms of transport; improve the efficiency of internal combustion engines; or switch to lower carbon fuels. The International Council on Clean Transportation provides a comparison of global vehicle efficiency standards. Figure 1-7 shows the global standards normalized to NEDC cycle in gCO2/km metric. Japan has had the toughest targets since the 1970s, but the EU has closed the gap in recent years. Japan is now in the process of determining a standard for passenger car fuel economy for 2020, and a formal proposal is expected by the third quarter of 2011.[49] There is a significant lag between the introduction of targets and the impact on the total vehicle fleet. For example, in the EU new passenger cars are about twice as efficient as the average for the whole car fleet.[50]

Figure 1-7: Evolution in vehicle emissions standards



Source: ICCT, 2011

In the EU, an ambitious compromise deal was agreed in December 2008, despite industrial pressures caused by the financial crisis. This will gradually limit CO2 emissions to 120 g/km for 65% of new cars in 2012, 75% in 2013, 80% in 2014 and 100% in 2015 (2004, 161g/km). A target of 130g/km is to be reached by improvements in vehicle motor technology. A further 10g/km reduction should be obtained by other technical improvements, such as better tyres or the use of biofuels. Between 2012 and 2018, the fine for non-compliance will be as follows: €5 for the first gram of CO2, €15 for the second gram, €25 for the third and €95 from the fourth gram of CO2 onwards. From 2019 manufacturers will have to pay €95 for each gram exceeding the target.

The Global Fuel Economy Initiative has proposed a target of 50% fuel economy improvement worldwide by 2050, with interim targets. It argues that the benefits are large and greatly exceed the expected costs of improved fuel economy. Cutting global average automotive fuel consumption (L/100 km) by 50% (i.e. doubling MPG) would reduce emissions of CO2 by over 1 gigatonne (Gt) a year by 2025 and over 2 gigatonnes (Gt) by 2050, and result in savings in annual oil import bills alone worth over USD 300 billion in 2025 and 600 billion in 2050 (based on an oil price of USD 100/bbl).[51]

Further emissions savings can be made by substituting petrol and diesel for sustainable biofuels in internal combustion engines. However, biofuels are at the centre of an often heated international debate involving questions of energy security, climate change, food prices, biodiversity conservation and social development.[52] Government policies to support the production and use of biofuels are motivated by their potential to reduce greenhouse gas emissions as an alternative to fossil fuels. But the record price spikes for food commodities in 2008, for example, have been blamed in part on the diversion of food crops for biofuel production. Other analysis has suggested that estimates of biofuels-related carbon benefits generally fail to include emissions from land-use changes.[53] The World Bank has drawn attention to the economic viability of current biofuel programs, including upward pressure on food prices as well as intensified competition for land and water.[54] Other critics have also raised concerns over social problems related to land use, often exacerbated by the lack of clear tenure rights. Growing criticism of biofuels has put many governments under pressure to rethink their policies. The EU, while retaining its target of 10 per cent biofuel requirement by 2020, has opted to include some sustainability criteria. The challenge for governments will be to provide this support in a way that is backed up by evidence and is sufficiently neutral to move towards the most promising biofuels. Second generation biofuels technology focuses on breaking down lignin and cellulose from woody substances to release sugars that can then be fermented in a process similar to first generation biofuels. This has the potential to greatly increase the volume of available material without competing with food crops and can achieve far higher greenhouse gas reductions. However the main technologies are not yet scaled up commercially and technical challenges remain. The impact of growing second generation biofuels on soil quality is also under consideration.

In the last few years electric vehicles have increasingly been considered as the most promising alternative to the internal combustion engine. Many developed countries and China have made commitments to deploy electric vehicles (see Table 1.5) The EV20 alliance of companies announced in September 2010 that its members would add one million EVs to the roads by 2015 compared with targets already announced by companies.

Table 1-5: EV targets

Austria	*2020: 100,000 EVs deployed*
Australia	*2012: first cars on road, 2018: mass deployment, 2050: up to 65% of car stock*
Canada	*2018: 500,000 EVs deployed*
China	*2015: 1,000,000 annual production of EVs*
Denmark	*2020: 200,000 EVs*
France	*2020: 2,000,000 EVs*
Germany	*2020: 1,000,000 EVs deployed*
Ireland	*2020: 10% EV market share*
Israel	*2011: 40,000 EVs, 2012: 40,000 to 100,000 EVs annually*
Japan	*2020: 50% market share of next generation vehicles*
New Zealand	*2020: 5% market share, 2040: 60% market share*
Spain	*2014: 1,000,000 EVs deployed*
Sweden	*2020: 600,000 EVs deployed*
United Kingdom	*No target figures, but policy to support EVs*
United States	*2015: 1,000,000 PHEV stock*

Source: Foley et al, 2010[55]

1.3.5 Renewable energies

The growth in the global renewable energy industry has been rapid in recent years. Direct investment in new renewable capacity rose from $8 billion in 1997 to $30 billion by 2004[56] and in 2010 totalled over $120 billion.[57] This level of growth far exceeds the growth of the more traditional energy sector, with from 2007 onwards globally wind energy attracted more annual investment than nuclear power or hydro power.

Europe continues to have the largest investment in low carbon energy for any region in the world – in 2010 new investment including mergers and acquisitions totally $94.4 billion. In the same year wind accounted for more new generation capacity in Europe than any other power source. The main reason for this level of investment is the clear, and now binding, requirement of Member States to increase the contribution of renewable energy. The introduction of a target calling for 20% of the EU's energy to come from renewable energy sources by 2020 is undoubtedly extremely ambitious as it will require a more than 3 fold increase from current levels. Experience in some Member States, in particular Denmark, Germany and Spain, shows that the right policies, those that create market certainty on the medium and long term, can rapidly drive the diffusion of technology.

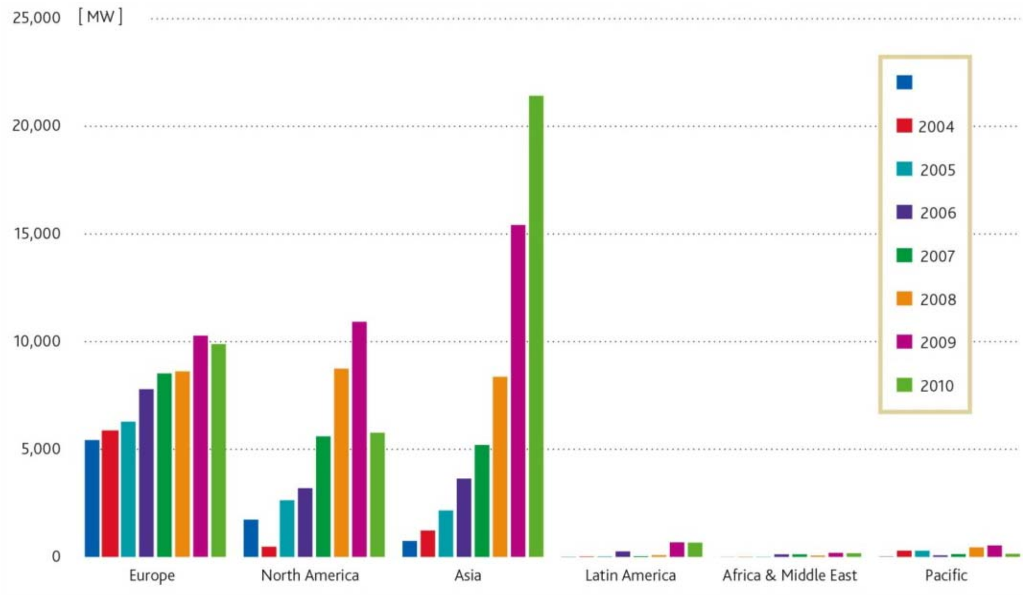
Across the United States, states, municipalities and utilities are putting in place mechanisms and targets to increase the use of renewable energy. The DSIRE web site list 37 states in which action has been taken to create specific targets for the use of renewable energy, for example in Florida the state utility is required to produce 7.5% of its electricity from renewable energy sources by 2015, or in Massachusetts all electricity retailers must produce 4% of their electricity from renewable sources by 2010. At a federal level, the US provides investment and production tax credits for renewable energy, which has helped encourage development of wind power in particular in recent years. The US leads the world in new wind power installations, accounting a quarter of the global total in 2007.

Brazil has the world's largest renewable energy market as a result of its hydropower and bioethanol programs. The government has mandated that 25% of all liquid transport fuel comes from bioethanol, however, this target is being exceeded, with production in 2008, of 22 billion litres, contributing nearly 40% of the total. The vast majority of this production is for domestic use, with only 3.8 billion litres exported in 2007.

In India the Government has set a target that by 2032, 10% of the country's energy must come from renewable energy. In order to achieve this specific targets have been put in place for the electricity and transport sectors. The growth in the wind sector is the most notable, with a proposal to move from 7.8 GW to nearly 20 GW by 2012. In 2007 1.7 GW of new capacity was added. However, to many this is just the beginning and Low carbon energy Finance predicts that by 2020, 42 GW is possible. Currently, the Indian Wind Turbine Manufactures Association estimate that the potential is in the order of 65 GW. In global terms India is the fourth largest wind energy generator employing around 10 000 people. Importantly, India has a major domestic turbine manufacturing base, which is used for domestic and the export market.

However, Asia, and particularly China are rapidly increasing their manufacturing and deployment of, in particular, wind power. The graphic below, shows how Asia has in 2009/10 overtaken both Europe and American annual deployment rates. The graphic also highlights the degree to which large markets, such as the Middle East are still to deploy wind power on any scale, suggesting the considerable global market that is yet to emerge.

Figure 1-8: Growth in Global Wind By Region



Source: Global Wind Energy Council 2011[58]

1.3.6 Carbon footprint

A 'carbon footprint' measures the total greenhouse gas emissions caused directly and indirectly by a person, organisation, event or product.[59] This allows individuals and companies (and potentially countries) to calculate the greenhouse gases released as a result of their activities. It is also a way to assess the emissions associated with a specific product along the supply chain, enabling consumers to make more informed choices.

Over 50% of an average corporation's carbon emissions are typically from the supply chain rather than within an organisation's direct activities and transport.[60] One of the major challenges is developing a consistent and comparable approach to carbon footprinting, given the methodological issues associated with, for example, defining system boundaries. Adding a carbon label to a product is a complex and often costly process that involves tracing its ingredients back up their respective supply chains and through their manufacturing processes, to work out their associated emissions.[61] Yet there is growing pressure on the private sector to assess and address emissions as part of corporate good practice. According to the Carbon Disclosure Project, 534 institutional investors controlling US$64 trillion in assets request disclosure from listed companies in whom they invest.[62] The expectation is that the cost of carbon will increasingly be internalised by companies, even while regulation remains patchy across the globe and despite the absence of a global binding agreement on climate change. By acting early they position themselves for future low carbon markets and avoid unnecessary costs.

Carbon footprinting activities in the UK since 2007 and now France have helped shape the two global product-footprinting standards that may provide the basis for a consistent international approach: ISO 14067, being drawn up by the International Organisation for Standardisation, and the GHG Protocol, a project backed by two environmental groups, the World Resources Institute and the World Business Council for Sustainable Development.[63]

The debate over where and how greenhouse gas emissions should be counted has been rising up the policy agenda in recent years as part of discussions over the future of international climate policy after 2012 (the end of the second phase of the Kyoto Protocol). Specifically, the question is whether emissions should be allocated to the country where the emissions have been released (a production based approach) as is the case at present, or where the end products have been consumed (a consumption based approach). Proponents of consumption based approaches make several arguments, such as: that consumers should be responsible for the full cost of their environmental impact; that consumption based approaches would require policy makers in developed countries to focus more on addressing the emissions embedded in high carbon traded commodities, thus having a greater environmental impact; and that it would improve the prospects for a global binding agreement on climate change, by encouraging the participation of energy intensive exporters. Proponents of the current system argue that in a global cap-and-trade system with given emission caps, switching from a production to a consumption based accounting system has neither efficiency nor distributive effects. Which countries would benefit from a switch depends on the precise structure of arrangements in the meantime, which is likely to complicate rather than simplify negotiations. They also argue that it introduces considerable methodological uncertainty (with a detrimental impact on environmental efficacy) as well as significant transaction costs.[64]

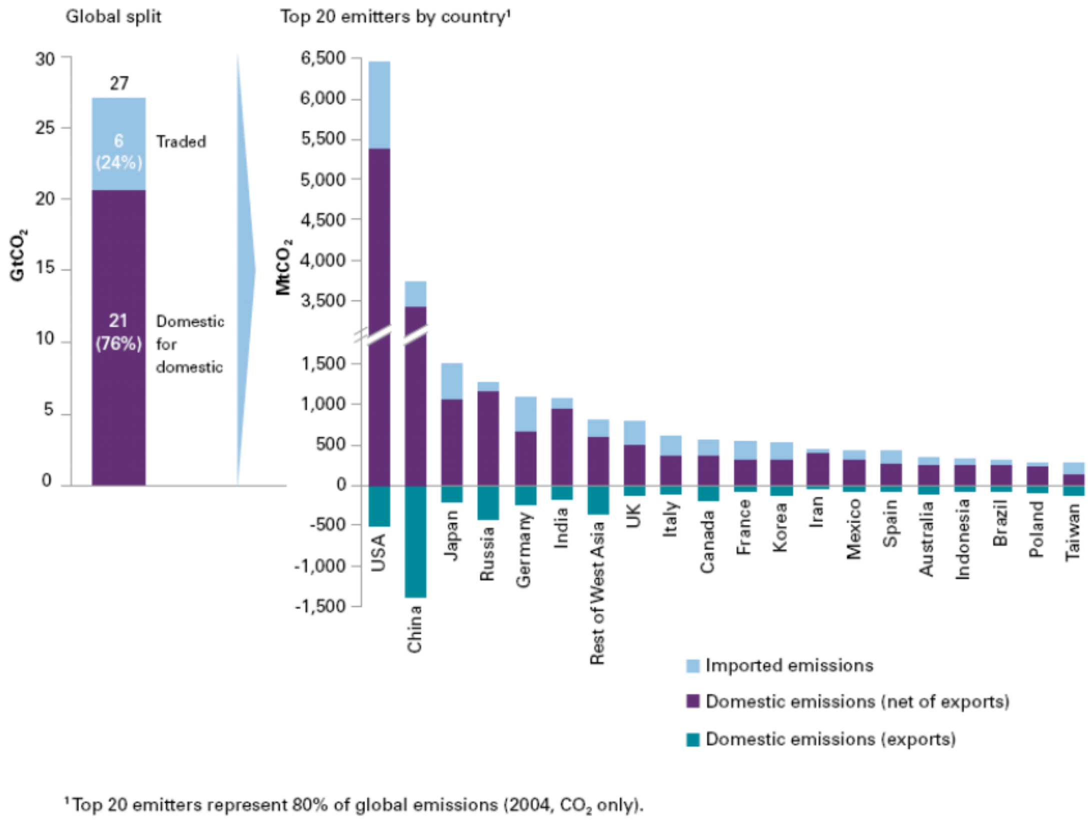
Whichever approach is used in the global climate regime however, the use of consumption based numbers can be useful to decision makers and the general public in understanding the environmental consequences of their policies. For example, recent analysis by Glen Peters et al shows that most developed countries have increased their consumption-based emissions faster than their territorial emissions, and non–energy-intensive manufacturing had a key role in the emission transfers. The net emission transfers via international trade from developing to developed countries increased from 0.4 Gt CO_2 in 1990 to 1.6 Gt CO_2 in 2008, which exceeds the Kyoto Protocol emission reductions.[65]

Another recent study by the UK's Carbon Trust provided the following conclusions:

- **Embodied carbon flows are large and growing.** Approximately 25% of all CO_2 emissions from human activities 'flow' (i.e. are imported or exported) from one country to another.
- **Embodied carbon imports are significant for many developed economies.** Major developed economies are typically net importers of embodied carbon emissions. UK consumption emissions are 34% higher than production emissions: Germany (29%), Japan (19%) and the USA (13%) are also significant net importers of embodied emissions. For some economies with very carbon efficient production processes, the relative importance of imported carbon is even greater. The high levels of net imports in France (43%) and Sweden (61%) reflect in part the low carbon intensity of their energy systems.
- **Many developing countries export embodied emissions in international trade** Developing countries are generally net exporters of CO_2 emissions. For example, in 2004 China exported ~23% of all its domestically produced CO_2.

- **Embodied carbon flows in both commodities and final products.** The flow of carbon is comprised of roughly 50% emissions associated with trade in commodities such as steel, cement, and chemicals, and 50% in semi-finished/finished products such as motor vehicles, clothing or industrial machinery and equipment.[66]

Figure 1-9: Production of CO2 emissions by country, and the import and export of CO2 emissions embodied in trade

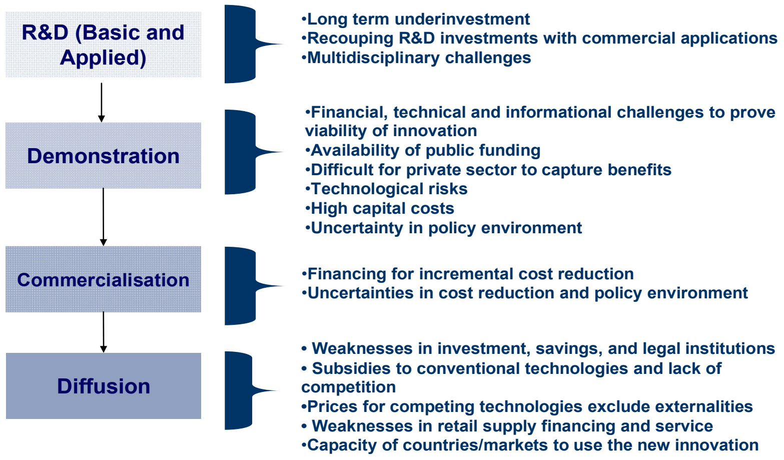


Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 EEBT Model (2004)

1.4 Accelerating innovation

Innovation is recognized across the G20 as central to future growth and competitiveness, especially in the context of the resurgence of global manufacturing. The focus is now often on green, efficient technologies – such as in energy, transport and buildings. Yet despite broad agreement on the importance of low carbon energy technology, there has been only slow progress on developing and implementing a practical and effective innovation system of incentives to drive the transition to a low carbon economy at scale. There are however barriers to innovation which can prevent or slow technological development anywhere from the early research and development phase through to the rolling out of the technologies. As Figure 1-10 shows, these barriers can occur at multiple points in the innovation chain. This is a simplification as in practice these elements interact in a dynamic fashion.[67]

Figure 1-10: Understanding barriers along the innovation chain



Source: UNDP (2000); OECD (2006); Chatham House and E3G (2007-08)

Overcoming these barriers and delivering low carbon technological options at scale is no mean feat at a time of volatile energy prices and the global economic downturn. A careful balance between private interests versus the delivery of global public goods is also critical, as are the needs of developing countries.

The race for low carbon technology solutions offers genuine opportunities for developed and developing countries to embrace new models of technological cooperation, whether at domestic, bilateral or multilateral level. For developing economies, it can provide an opportunity to increase its share of value addition through the production of low carbon goods and services. This will enhance the prospect of de-linking their economic growth from environmental harm. The size of the emerging economies' markets – and their potential manufacturing might – also offers some economically viable pathways to drive down the costs of the energy transition, while building new markets for its low-carbon goods and services.

While the traditional concept of 'technology transfer' implies a process through which a piece of equipment or a blueprint is transferred to a recipient company or country, this is only half the story. Moving up the technology ladder is as much about access to the physical hardware as it is about acquiring the knowledge and know-how to use it effectively. Technological innovation is needed across a broad range of areas, encompassing high technology, materials, industrial process, consumer products and business practice

Box 1-5: India: Japanese-Indian: Joint initiative on Smart Communities[68]

In January 2011 a consortium of five heavy industrial companies (Mitsubishi Heavy Industries, Ltd. (MHI) , Mitsubishi Electric Corporation, Mitsubishi Corporation, Mitsubishi Research Institute, Inc. and the Electric Power Development Co., Ltd. (J-POWER)) signed a Memorandum of Understanding with the State Government of Gujarat to promote the development of a Smart Community, which creates energy-conserving, low-carbon, next-generation urban infrastructure through the introduction of advanced energy-saving technologies and urban transportation systems. This is a part of the larger Delhi Mumbai Industrial Corridor development, which is connecting industrial parks, power plants, airports, ports, railways, roads and commercial facilities. The partnership will target business development opportunities in high-efficiency power generation systems leveraging natural gas and power generation systems using renewable energies, such as solar thermal, as well as promoting electrification in the transportation sector.

It is critical not to overlook the range of substantive gains to be achieved through the diffusion of incremental technologies (e.g. improved insulation and furnace technologies) as well as of 'soft' practices (e.g. congestion charges, industrial process optimisation training, lean manufacturing/ quality management and SCADA systems). These soft practices and incremental improvements also have different barriers to implementation than large-scale capital investment in horizon technologies. While many of the critical technologies have already been developed, it is important to pursue the high-tech and 'disruptive' technologies (important in many energy scenarios) to move onto a low-carbon path,

The development of energy technologies rarely follows a linear logic or evolves within the boundaries of individual economic sectors. Many breakthrough innovations occur when different fields interact. For example, innovation in solar PV technologies has benefited from developments in consumer and industrial electronics, and advances in CSP derive from aerospace and satellite technologies.

Innovation in the supporting infrastructure for low carbon technology deployment will also play a vital role (e.g. such as the charging network for electric vehicles and grid extensions to connect dispersed renewable energy generation). There has been considerable interest in "smart grid" innovation in recent years, since a more flexible model for electricity would allow for greater penetration of renewables and better demand management, spreading demand so that less generating capacity is needed at peak times. Box 1-6 explains the trends on smart grid innovation in key countries.

Box 1-6: Smart Grids

A rapid rise in the market size of smart grids has been forecast by an array of studies. However, as well as the usual uncertainties that existing with market predictions, looking to the future for smart grids has additional problems, namely:

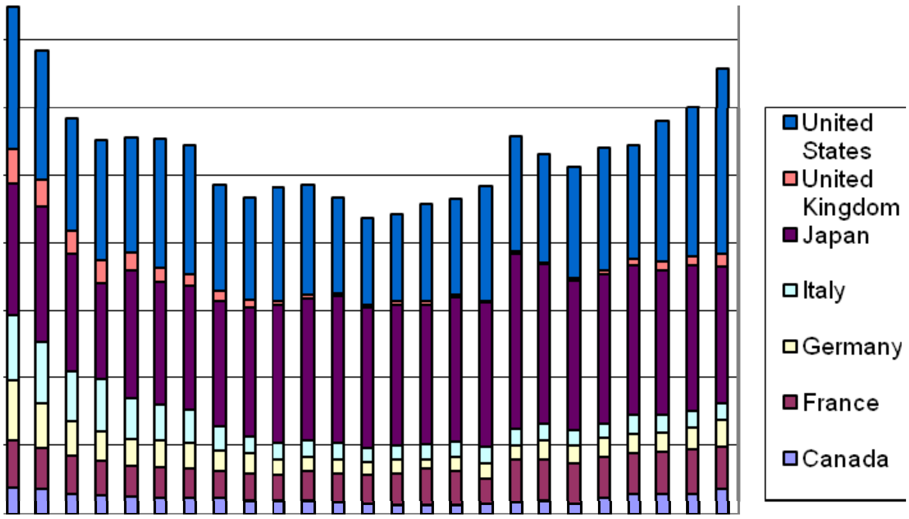
- That many of the technologies are relatively new and the production costs of global diffusion as less certain
- There will be significant costs associated with the installing of new equipment
- There is no universal definition of a 'smart grid' and therefore no benchmark by which cost comparisons can be made
- Many investment costs which are either for the necessary upgrading of transmission and distribution equipment or the installation of new systems may be defined as 'smart'.
- There is a mixture of public and private finance expected in the smart grid, which can distort investment patterns and definitions, in the US the market is expected to grown to $9.6 billion by 2015 assisted a $3.4 billion in federal stimulus grants[69].

1.4.1 Building capacity on research and development

Even though global R&D investment is mostly undertaken in the private sector and is increasingly global in nature[70], government action and public policy can help leverage the power of private markets to solve low carbon innovation challenges.

While public spending on overall R&D increased by 50% between 1988 and 2004, public energy-related R&D declined 20% over the same period of time. However, in recent years, in part as a result of the stimulus packages, energy expenditure has increase in a number of countries, while overall over the same period private sector R&D in energy decrease.[71] The other trends to note are that there is a strong bias towards certain technologies. Nuclear power (both fission and fusion) has received over half of all state R&D budgets from the G7 countries over the last two decades, more than five times the combined energy efficiency budgets and that innovation in climate mitigation technologies is concentrated in a few countries: Japan (42% of total patents), Germany (13%), US (12%), China (6%), South Korea (5%) and Russia (4%).[72]

Figure 1-11: Public energy-related R&D spending in G-7 countries, 1985-2009 (Million US$ 2009)



Source: IEA database of R&D, 2011[73]

In 2005, businesses accounted for almost 63% of R&D funding in OECD countries. It funds three-quarters of R&D in Japan and 65% in the United States, but only 54% in the European Union. However, government remains the major source of R&D funding in almost one in four OECD countries. On average around 7% of R&D performed is financed by direct government funds mainly due to trends of increasing adoption of other policy instruments to stimulate innovation (e.g. R&D tax incentives).

Box 1-7: Alternatives to high carbon products and approaches

Innovation will play a critical role in improving the products and technologies that are already part of our daily experience – from cars to electronic goods and buildings to more efficient coal power plants. But given the scale of the climate change challenge and concerns about resource constraints, China's vision of low carbon Industrialization in the 2020s needs to consider the role of alternatives to existing products, materials and industrial methods. Could there, for example, be an alternative to cement or steel in construction?

A new market for sustainable products and low carbon commercial vehicles are at the forefront of this trend. There is definitely evidence that consumer demands are shifting in favour of sustainable products, for example, the rise in sales of hybrid cars (2,200% since 2000 in the US alone). Despite fears that the current economic climate will discourage demand for more costly, sustainable products, consumer understanding of environmental performance is on the increase – and in some products, such as hybrid cars and energy efficient light bulbs, there is recognition that resource efficiency reduces expenditure. These new developments, which are particularly apparent in the automotive industry, are creating momentum for a sustainable, low carbon economy and adding to expectations and challenges of corporate, particularly in the developing world.

Insufficient attention has been paid to developing alternatives for these highly emissive goods despite the fact that successful creation of such will significantly improve efficiency and produce sustainable products that are less vulnerable to resource scarcity and appealing to the changing consumer market.

Bridging the gap between the R&D phase to full scale commercialisation can represent a significant limiting factor in the uptake of new technologies. The size and complexity of demonstrating these new technologies, which often includes intricate planning and infrastructural support, make it difficult for the private sector to independently finance. This is particularly the case with large scale or unproven technologies, such as CCS and biorefineries. Public funding, public-private partnerships and joint ventures are an effective way of raising the necessary capital and for pooling expertise essential to getting a new project off the ground.

The collaborative project between pulping giant Weyerhaeuser, the Swedish company Chemrec and the US the US Department of Energy saw the piloting of the first full-scale high-temperature, black liquor gasifier at the North Carolina facility[74]. This technology made it possible to achieve higher overall energy efficiency in the paper-pulping process by recovering an energy-rich syngas from the pulping by-products. More recently, Chemtec attracted EU funding for the development of a demonstration plant for the production of bio-methanol and other biofuels from black-liquor pulp mill residue.[75] The project is expected to generate important external benefits, contributing in particular to knowledge spill-over, environmental protection and regional development as well as enhancing the subsequent industrial uptake of the new technology with a significantly lower level of risk.

Innovation is increasingly becoming international both in terms of finance and actual research. The average R&D intensity of affiliates under foreign control is higher than the R&D intensity of domestically controlled firms in most countries.[76]

In 2005, China became the third largest R&D spender worldwide (in purchasing power parity terms) after the United States and Japan. Emerging economy firms are also increasingly investing in developed countries. A recent study showed that Chinese firms alone set up 37 R&D units abroad of which 26 are based in developed countries (11 in the USA and 11 in the EU)[77]. Emerging economy firms have also acquired developed country firms in order to gain access to their intellectual property and markets.

Environmental and resource constraints will make it increasingly difficult for emerging economies to follow the 'traditional' pathway to Industrialization. Stating the unsustainability of the traditional Industrialization model, however, is insufficient to trigger a sea-change in approach. It therefore crucial that both developed and developing countries actively pursue an alternative strategy for growth, by encouraging and collaborating on low carbon innovation, and that they demonstrate how and why the effects of decarbonisation could be positive overall for industrial development, applicable to key industries and implemented without compromising efforts to deliver infrastructure.

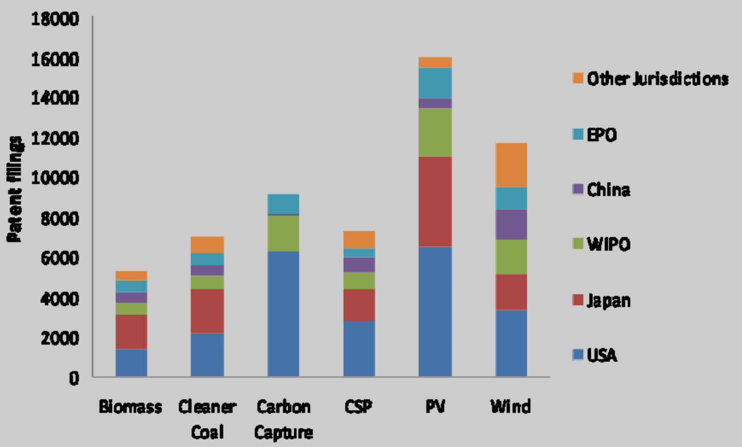
A substantial strengthening its innovation base is the best way for China to position itself. There is little alternative for China but to generate the range of options and the flexibility to thrive in future years. Research, development, deployment and associated infrastructure as well as continued investment in key sectors will play a key part. But China must also look more broadly, building up education and human capital at all levels and stimulating a culture of innovation across society.

There is no doubt that China has the capacity and the need to become a global leader in sustainable development and innovation in environmental technology and Chinese leaders have long recognized that a more sustainable model of development is required given constraints on resources and environmental impacts.[78] But no one country will hold the keys to the low carbon economy. Collaboration on the development and supply chains of key technologies will be vitally important. China must maintain a vision of open innovation and investment to ensure the flexibility that is necessary for a prosperous future.

Box 1-8: China and low carbon energy innovation

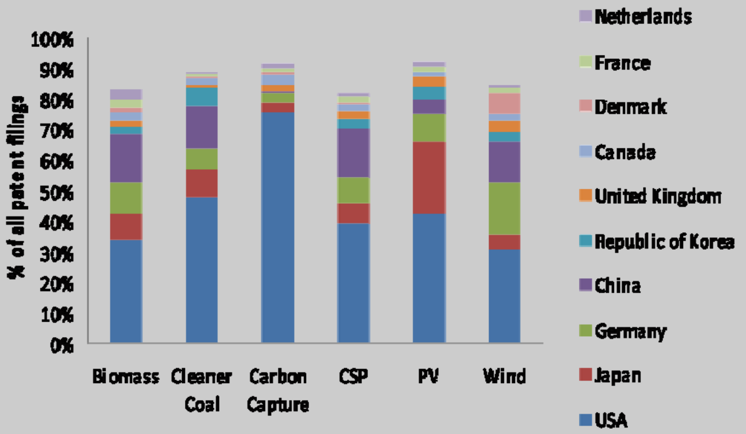
The geographical distribution of patenting and how this changes over time provide an indication of innovative activity and trends. China is increasingly popular as a destination for patent filing, which reflects an intention to invest, sell or license a technology. This is not surprising given of the size of the potential markets in China:

Patent Filing Locations for Six Energy Technologies



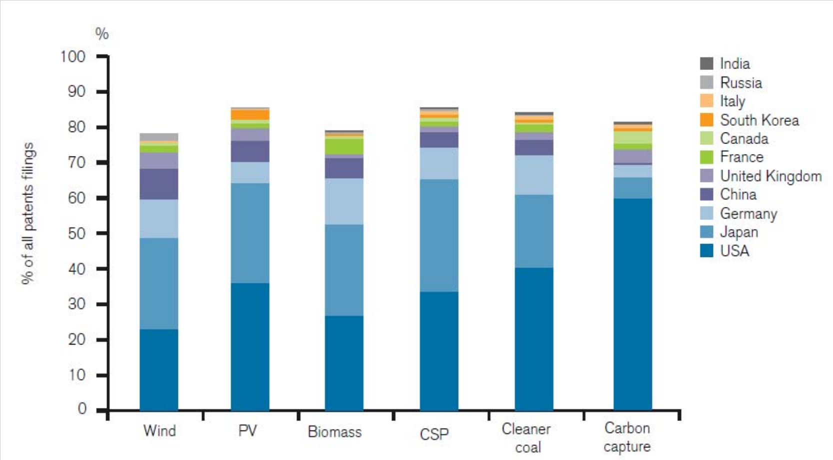
The origins of the patenting organisation shows where research and development activity is taking place. The US is far ahead by this measure, but China has recently joined Japan and Germany in the next tier down:

Patent Assignee Origins



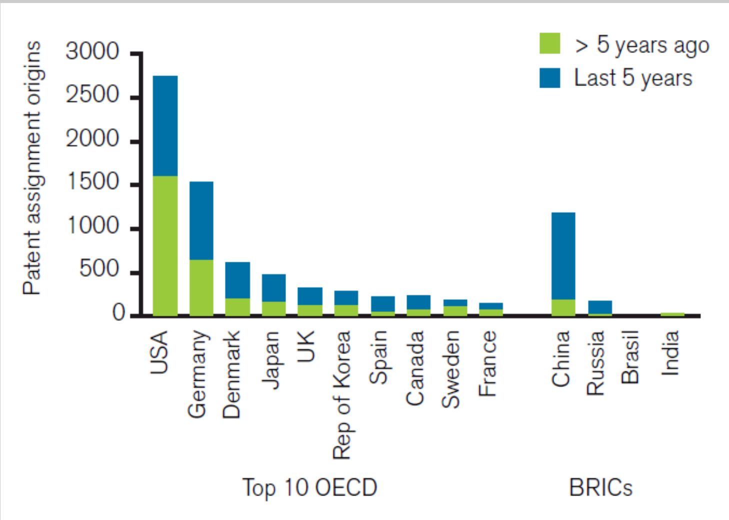
Innovation is still dominated by OECD actors, who will determine the diffusion speed of the most advanced energy technologies in the next decade. The next chart shows the geographical origin by parent company. Here, China lags further behind the US, Germany and Japan. This is because many companies that record their "origin" as China are in fact local subsidiaries of Japanese and US firms.

Patent Assignee Origins (parent companies), firms with >4 patents only



However, China is catching up fast, as the example of wind power demonstrates. In the last five years, firms based in China have registered more patents than anywhere outside the US:

Patent Assignee Origins – Wind Power



Source: Chatham House, 2009

1.4.2 Managing new resource risks

The development of low carbon energy resources – as with the conventional resources that they seek to displace – come with new material and environmental risks. These risks include:

- Access to materials or fuels needed for the manufacture or use of the low carbon energy source
- The resource use – particularly if there is an impact on water or land use
- Use of equipment, materials or fuels for military means – the dual use capabilities

For example, rare earth metals (REMs) are a group of 17 elements (atomic numbers 57-71 along with Scandium and Yttrium) whose unique properties make them indispensable in a wide variety of advanced technologies. They are an important example of material scarcity and the 'third energy revolution'.

China's accelerating consumption of its own rare earth resources risks leaving the rest of the world without a viable alternative source. Today, access to REMs for low carbon energy production is already creating trade tensions between China and the US. However, REMs are not the only elements needed for low carbon energy technologies; Table 1-6 below shows a range of other materials that will needed in significantly greater volumes.

Table 1-6: Material Use on Low carbon energy Sources

	Raw materials (application)
Fuel cells	Platinum Palladium Rare earth metals Cobalt
Hybrid cars	Samarium (permanent magnets) Neodymium (high performance magnets) Silver (advanced electromotor generator) Platinum group metals (catalysts)
Alternative energies	Silicon (solar cells) Gallium (solar cells) Silver (solar cells, energy collection / transmission, hi gh performance mirrors) Gold (high performance mirrors)
Energy storage	Lithium (rechargeable batteries) Zinc (rechargeable batteries) Tantalum (rechargeable batteries} Cobalt (rechargeable batteries)

Source: Materials Innovation Institute, November 2009[79]

The production of energy can compete with resources previously destined for other uses. The most well-known example relates to the production of first generation biofuels and the development of coal to liquids, both being developed primarily to combat security of supply concerns around oil.

The widespread availability of coal has encouraged some countries – including, Australia, China, India and United States – to seek development of its use as a liquid transport fuel. However, despite the abundance of coal in these regions there are environmental constraints, over water in particular. Such use necessitates water requirements in the order of 5-10 litres for every litre of fuel output. This has already had an impact on the development of sector with a plans rejected for the construction of a projects in China[80].

Facing possible scarcities of REEs due to supply-side constraints has driven research into discovering adequate substitutes as well as the redesigning of products to avoid use altogether.

Rare earths are used in permanent motors of hybrid electric vehicles and electric vehicles. Already commercially available alternatives include a number of asynchronous motor designs but ongoing research hints at alternatives to pure Neodymium permanent motors. For example the German government included its National Development Plan for e-Mobility, research on reluctance motors which offer greater performance and lower Neodymium content.[81] More broadly, Germany's €500million allocation for electric vehicles aims at stimulating research in a multitude of key technologies, addressing all the subsystems required to support the larger electric vehicle network; including battery development and integration, energy management, and new materials research. The 2020 vision of the Federal Government is 1 million EVs on the road and a world leading manufacturing status.

Another emerging trend within this realm of scientific research is the potential of nanotechnology to greatly enhance the novel properties of certain critical minerals or even open up entirely new avenues for alternative product designs. The application of nano-sized rare earth compounds are being considered in green technologies such as magnets, batteries, fuel cells, H2-storage and catalysts

Scientists at National Institute of Advanced Industrial Science and Technology (AIST), Japan, have developed an advanced composite material partly consisting of multi-walled carbon nanotubes which when used in dye-sensitised solar cells, exhibits photoelectric conversion efficiency as high as that of the conventionally used platinum.[82] The United States Department of Energy national laboratory sees nano-structured permanent magnets as a key strategy to lowering the rare-earth content in the permanent magnets. The DOE, through its Advanced Research Projects Agency-Energy (ARPA-E) fund, supports both low-risk, evolutionary projects and high-risk, high-payoff experiments. One ARPA-E project has funded General Electric Global Research (GE) in developing next-generation permanent magnets with a lower content of critical rare earth materials. For the $2.2 million project, GE is developing bulk nanostructured magnetic materials with a dramatic increase in performance relative to state-of-the-art magnets. These new magnets will increase the efficiency and power density of electric machines while decreasing dependence on rare earth minerals. If successful, this project will lead to technologies for scaled manufacturing of low-cost, reduced rare earth-content, high-energy-density PMs [83]

2 THE FOUNDATION OF AND CHALLENGES FOR CHINA'S LOW CARBON INDUSTRIAL TRANSFORMATION

2.1 Domestic Background

2.1.1 China is in the medium term of Industrialization.

According to the 2008 China's Industrialization Report by Chinese Academy of Social Sciences, China had already entered the second half of industrialized metaphase in general, but situation varied in districts: Beijing and Shanghai already realized Industrialization; Tianjin and Guangdong were in the second half of latter period of Industrialization; Zhejiang, Jiangsu, Shandong were in the first half of that period; Liaoning and Fujian were in the second half of industrial metaphase; Ten provinces and districts including Shanxi and Inner Mongolia were in the first half of that period; Ten provinces including Henan and Hunan were in the second half of the initial phase; Guizhou was in the first half of that period; Whilst Tibet is in the pro-Industrialization phase.

China has already established itself as the largest energy consumer and 2nd largest economic body in the world. For main indicators of China's energy and economy, please refer to Table 2-1.

Table 2-1: Main Indicator of China's Energy and Economy

	1990	2000	2005	2006	2007	2008	2009	2010
Population/million	1143.3	1267.4	1307.6	1314.5	1321.3	1328.0	1334.7	1339.2
GDP/RMB 100 million	18668	99215	184937	216314	265810	314045	3400983	397983
Economic Structure/%								
Primary Industry	27.1	15.1	12.1	11.1	10.8	10.7	10.3	10.2
Secondary Industry	41.3	45.9	47.4	47.9	47.3	47.5	46.3	46.8
Tertiary industry	31.6	39.0	40.5	40.9	41.9	41.8	43.4	43.0
Per Capita GDP/USD/Person	344	949	1808	2070	2652	3414	3748	4396
Primary Energy Consumption /Mtce	987.0	1455.3	2360.0	2586.8	2805.1	2914.5	3066.5	3250.0
Dependence on oil imports /%	-18.4	26.4	36.4	39.7	43.2	46.9	51.7	54.5
Per Capita Energy Consumption /kgce	864	1148	1805	1968	2123	2195	2297	2424
Power Generation/TWh	621.2	1355.6	2500.3	2865.7	3281.6	3495.8	3714.7	4206.5
Steel Output/Mt	66.4	128.5	353.2	419.2	489.3	503.1	572.2	626.96
Cement Production/Mt	209.7	597.0	1068.9	1235.0	1361.2	1423.6	1644.0	1806
Total Export Value/100million USD	621	2492	7620	9689	12178	14307	12015	15779
Total Import Value/100million USD	534	2251	6600	7915	9560	11326	10059	13948
Average Exchange Rate (CNY/USD)	4.7832	8.2785	8.1943	7.9734	7.6075	6.9444	6.8310	6.7695

Source: National Bureau of Statistics (NBS)

China's economy and energy consumption differs in districts, with great gaps between rural and urban areas, between rich and poor. In 2008, the highest per capita GDP was 9.4 times higher than the lowest per capita GDP area. Teamed in 10%, the highest average per capita family income in urban area was 65 times higher than that of the lowest in rural area (Wang Xiaolu, 2010). There is an 11 times gap between the region with the highest individual power consumption and that with the lowest. There are families that used as low as 1.1 KWH/month on average (survey data from State Grid Corporation. 21 provinces/districts of China has had electricity access and this figure was the average value taken from the poorest peasant families) and there are 500m2 villas that use 2000KWH of electricity per month on average. According to International Standard, there was still an impoverished population of 150million. This is a reflection of the unbalanced, incoherent and unsustainable social development. Urbanization propels heavy Industrialization.

In 2010, China's primary energy consumption reached 3250Mtce, increased by 125% compared to that of 2000.

The acceleration of urbanization is the main reason for upsurge of energy need. Urbanization and increase of citizens' disposable income initiated the upgrading of consumption structure. Need for Houses, cars, domestic appliance are growing like never.

From 2000 to 2010, China's urbanization rate rose from 36.2% to 49.7% and there was an increase of 206.5 million in urban population. According to data provided by NBS, Agricultural Department and survey data in 2007, the energy consumption of urban citizens was 3.7 times that of rural residents, and per capita power consumption was 4.6 times.

From 2000 to 2010, the disposable income of urban citizens raised from RMB 6280 to RMB 19109, 1.7 times increase. The per capita net income of rural residents was RMB5919, 30% that of the urban citizens in 2010. The per capita housing area increased from 20.3m2 in 2000 to 31.6m2 in 2010. Family cars owned by every 100 families increased from 0.5 to 13.1, air conditioner from 30.8 to 112.1 and refrigerators from 80.1 to 96.6. See Table 2-2: for details. Urbanization was accompanied by consumption structure upgrading, driving a new round of heavy Industrialization. The output value of heavy industry accounted for 52.7% of the total industrial output value in 1995, 60.2% in 2000 and 70.5% in 2009. The energy consumption of heavy industry per unit of output value is about 4 times that of light industry. High energy consumption products like steel and cement developed at full speed. From 2000 to 2010, raw steel production increased from 128.5 Mt to 627.0 Mt, cement from 597.0 Mt to 1880.0 Mt, 3.9 and 2.1 times respectively.

Table 2-2: China's Urbanization and Energy Consumption

	2000	2005	2008	2009	2010
Urban Population/million	459.1	562.1	606.7	621.9	665.6
Urbanization Rate /%	36.2	43.0	45.7	46.6	49.7
Amount of Cities with Prefectural level and above		286	287	287	
>4million (population)		13	13	14	
2~4million (population)		25	28	28	
1~2million (population)		75	81	82	

Urban Per Capita Disposable Income/ RMB	6280	10493	15781	17175	19109
Urban Per Capita Housing Construction Area/M2	20.3	26.1	30.6*	31.3*	31.6*
Urban Family Cars Popularizing Rate/Amount/100families	0.5	3.4	8.8	10.9	13.1
Urban Family Air Conditioner Popularizing Rate/Amount/100families	30.8	80.7	100.3	106.8	112.1
Urban Family Refrigerator Popularizing Rate/Amount/100families	80.1	90.7	93.6	95.4	96.6
Urban Central Heating Area/100million M2	11.1	25.2	34.9	35.6	
Urban Per Capita Electricity Consumption /kWh	217	306	397	429	445

*Number with * is based on evaluation.*

Sources: NBS, China Electricity Council and Housing and City and Countryside Ministry of Construction

In 2009, China's construction industry consumed 284Mt of steel, covering 50.8% of the total steel consumption, of which housing construction took up 36.1%, infrastructure like roads 14.7%, cars 3.1% and domestic appliance 1.5%. China's steel consumption in construction industry covered 1/4 of the world total steel consumption. Cement consumption in the industry reached about 1460Mt, accounting for 90% of domestic total consumption and half of the global cement consumption.

China is at the peak of residential construction and there is also great growth room for the need for cars and domestic energy consumption equipments. These three are driving the rapid growth of heavy industries, e.g. steel, building materials, power, petrifaction, engineering machinery, power equipments and auto.

China's heavy Industrialization is to last for another 10 years at the least. The output of the high energy consumption products are expected to reach their peak around 2020, with peak steel output of 1billion tons (Chen Kesi, 2010; Yu Huabin, 2010).

2.1.2 The Prospects of China's Manufacturing Industry

According to the present industries and industrial classification in China, industry is divided into light industry and heavy industry. From the perspective of energy consumption, some light industries are high energy consumption ones, such as paper making, synthetic fiber and domestic glassware, while industries with energy consumption per unit of output value only 4% that of steel industry, such as communication equipments, computers and other electronic equipments are listed as heavy industries. (Domestic film and television and audio supplies belongs to light industry.)

To analyze industrial energy saving, we have to distinguish between high energy consumption industry (energy intensive) and low energy consumption industry. High energy consumption industries include steel, non-ferrous metal, building materials, petroleum and chemical engineering, paper making and chemical fiber. These industries' average energy consumption per unit of output value is 10 times that of light industries.

China's Secondary Industry accounted for 46.9% of the total GDP in 2010, of which industry covered 40.2% and construction 6.6%. In 2007, that number was 22.4% in USA; 30.1% in Japan and Germany; 29% in India and 28.0% world average (The World Bank). China's secondary industry proportion stood high for years, and highlighted the unbalanced industrial structure. To get out of this means to mainly rely on the growth model of manufacturing.

1. China's manufacturing industry boasts a large scale.

China's manufacturing industry boasts a large scale and fast development. At the end of 2008, there was 1.753 million manufacturing business entities, with a staff team of 103.6 million (See Table 2-3). In 2010, China's manufacturing output value took a proportion of 19.8% of the world, exceeding the USA, who was 19.4% and listed the first place (IHS Global Insight, 2011)

Table 2-3: China's Energy and High Energy Consumption Enterprises (2008)

	Business Entities Amount /10thousand	Employees/10 thousand	Total Profits(10million RMB)
Industrial Total	190.3	11738.3	33854.3
Coal Mining and Washing	2.1	570.7	2490.4
Petroleum and Natural Gas Exploration	0.1	110.8	4605.2
Manufacturing	175.3	10359.3	24486.5
Petroleum Processing, Coking and Nuclear Fuel Processing	0.6	91.4	□990.7
Chemical Material and Chemical Products Manufacturing	9.3	557.0	2058.4
Nonmetallic minerals mining products	20.6	932.9	1987.7
Ferrous Metal Smelt and Extension Processing	1.8	329.7	1604.8
Non-ferrous metal Smelt and Extension Processing	2.1	202.5	873.6
Electric and Heating Power Production and	3.7	311.2	569.6

Supplies			
Gas Production and Supplies	0.3	22.4	126.3

Source: NBS, the 2nd National Economic Census Main Data Bulletin, released in December 25, 2009.

2. The energy consumption proportion of China's industry is on the high side.

According to international energy balance definition and calculating methods, in 2009, China's industrial sector energy consumption made up 57.3%(energy used as raw materials is not taken into consideration) of the nation's total terminal energy consumption (See Table 2-4), much higher than that of global average level in 2008, which is 27.9% (see Table 2-5) and about same as that of Japan in the early 1970s.

Table 2-4: Consumption and Structure of Terminal Energy in China Subsector

	1980		2000		2005		2009	
	Mtce	%	Mtce	%	Mtce	%	Mtce	%
Agriculture	31.4	6.9	40.2	4.9	57.5	4.0	56.1	3.4
Industry	277.0	61.4	489.2	59.2	905.7	62.7	1210.8	62.8
Communications and Transportation	36.0	8.0	134.8	16.3	198.7	13.7	295.4	15.4
Civil, Business and Others	107.3	23.7	170.9	19.6	383.3	19.6	352.2	18.4
Total	451.7	100.0	871.7	100.0	1445.2	100.0	1590.8	100.0

Note: 1.The Table is based on China's Overall Energy Balance Table and calculated by international energy balance definition and methods. Terminal Energy Consumption equals to Amount of Primary Energy Consumption minus energy amount that consumed in processing, transforming, storage and energy industrial consumption.

2.The proportion of energy consumed by the industrial sectors other than energy used as raw materials is 57.3% in 2009.

Table 2-5 Global Terminal Energy Consumption Structure (2008) Unit: Mtoe

	Total Consumption Amount	Subsector Consumption			
		Industry	Transportation	Civil/Business/Agriculture	Non-energy use
China	1379	657(47.8)	156(11.3)	426(30.9)	139(10.0-)
USA	1542	295(19.1)	609(39.0)	491(31.8)	155(10.1)
EU□27□	1219	295(24.2)	330(27.1)	455(37.3)	139(11.4)

Japan	320	87(27.3)	78(24.5)	113(35.4)	41(12.8)
OECD	3696	849(23.0)	1191(32.2)	1229(33.2)	427(11.6)
Global Total	8423	2351(27.9)	2297(27.3)	2850(33.8)	923(11.0)

Note: the number inside parentheses is proportion

Sources: Institute of Energy Economics Japan, Japan Energy and Economic Statistics Brochure 2010

3. Prospects of China's Manufacturing Industry

China's the world's biggest production and consumption nation of high-energy consumption products. In 2009, China's production of steel, cement, plate glass, architectural ceramics, chemical fertilizer, chemical fibers and auto took up 47%, 60%, 50%, 65%, 35%, 57% and 25% respectively. See Table 2-6 and Table 2-7.

Table 2-6: High Energy Consuming Products and the Production of Terminal Energy Consumption Equipment

	1990	2000	2005	2006	2007	2008	2009	2010
High Energy Consumption Products								
Raw Steel /Mt	66.4	128.5	353.2	419.2	489.3	503.1	572.2	626.96
Cement/Mt	209.7	597.0	1068.9	1236.8	1361.2	1423.6	1644.0	1880.0
Electrolytic Aluminum /Mt	0.85	2.79	7.79	9.27	12.34	13.17	12.89	15.65
Ethylene /Mt	1.57	4.70	7.56	9.41	10.48	9.88	10.73	14.19
Farm-oriented Chemical Fertilizer /Mt	18.80	31.86	51.78	53.45	58.25	60.28	63.85	67.41
Terminal Energy Consumption Equipment/Million								
Auto	0.51	2.07	5.71	7.28	8.89	9.31	13.80	18.27
Refrigerators	4.63	12.79	29.87	35.31	43.97	48.00	59.30	73.01
Color TV	10.33	39.36	82.83	83.75	84.78	91.87	98.79	118.30
Air Conditioners	0.24	18.27	67.65	68.49	80.14	81.47	80.78	108.99

Source: NBS

Table 2-7 Global Share of China's Energy and Energy Consumption Products Production (2009) (Unit: %)

Population	1.33474billion	19.5
GDP	4984.7billion USD	8.5
Primary Energy Consumption	3066Mtce	19.5
Petrol Consumption	384Mt	10.4
Coal	2973Mt	43.3
Electricity Generation	3714.7billion kWh	18.5
Steel	57.2million t	46.6
Cement	1.64billion t	60
Plate Glass	58.6million weight cases	50
Architectural Ceramics	6.8billion m2	65
Chemical Fertilizers	63.9Mt	35
Auto	13.80million units	25
Yarn	23.94Mt	46
Chemical Fibers	27.3Mt	57
Air Conditioners	80.78million	70
Refrigerator s	59.3million	60
Color TVs	98.79million	48
Microwaves	60.38million	70
Microcomputers	18.2million	60
Mobile Phones	61.9million	50
Photovoltaic Batteries	4382MW	46.9
Compact Fluorescent Light	3.65billion	80

Sources: NBS; Ministry of Industry and Information Technology; the World Bank; IMF BP Statistical Review of World Energy , June 2010 China Economic Information Network; People's Net; China Iron and Steel Industry Association; China Nonferrous Metals Industry Association; China Building Materials Industry Association; China Ceramics Industry Association; China Household Electrical Appliances Association and China Association of Lighting Industry

With low-cost labor and inexpensive resources and environment, China's manufacturing industry boasts many products that secure unapproachable competitive edges. With the increasing labor, resource and environment costs, China's traditional low-end industry tends to lose its edges. However, the average salary of China's manufacturing workers is still only a few percent of that in developed nations. Though the neighbouring countries may have cheaper labors, China's big market and competitively well-established industrial chain and infrastructure still holds strong investment attractions. More importantly, with vast territory, its domestic regional diversity is larger than domestic and international differences. Shanghai's income level is 10 times apart from that in Guizhou and a uniform market is still on its way. Part of China's middle and west still have a large amount of surplus labor and their cost is lower than that in the east coastline. Securing this as an opportunity, the coastal areas have already started its industrial upgrading swiftly with traditional industry moving inner direction. Middle and western China is becoming the new engine for China's economic development to boost China's sustainable rapid growth.

On the other hand, industrial upgrading doesn't mean elimination of labor intensive industries, but rather including the increase of its products' technology content. China needs to continue developing labor-intensive industries to take in a large amount of rural labors. The World Factory has taken in 200million rural labors. With restructuring and industrial upgrading, the ability of manufacturing to absorbing labors shall decrease.

2.1.3 Imbalance of China's Technologic Development

1. Remarkable progress of China's industry

Over the past ten years, China has made remarkable progress in industry development, with a number of large enterprises having reached international advanced level so far, such as Shenhua Group, Huaneng Group, China National Building Material Group, Conch Group, Baosteel Group, and Aluminum Corporation of China etc. China is ahead of America in 7 technologies, including ultra high voltage AC and DC transmission, high speed railway, supercritical and ultra supercritical thermal power generation, low carbon energy car, renewable energy sources and super computers. (by U.S Secretary of Energy, Steven Chu, December, 2010). China also takes the lead in clean coal utilization and renewable energy source development. See Table 2-8: and Table 2-9:.

Table 2-8: China's Progress in Clean Coal Technology (2010)

Coal Preparation	Washing 1650Mt of raw coal, accounting for 50.9% of raw coal output, saving 160Mt of coal and reducing emission of 7.7Mt SO2 and320Mt of CO2.
CWS	Annual production capacity reaches 80Mt, 30Mt of which is used as fuel for power plant, industrial boiler and furnace and 50Mt of which is used as gasification material. Compared with direct burning, coal gasification can save energy and reduce emission at least by 10%.
Ultra supercritical thermal power generating units	33 1000MW units in operation and 11 more under construction. Thermal efficiency at 45.5% and coal consumption of power supply at 283gce/kWh, 52gce/kWh less than the average level of 2010. The 33 units save 8.4Mtce coal and reduce emission of 22.8Mt CO2 every year.
Circulating fluidized bed boiler	17 300MW boilers in operation, 50 more under construction or proposition and the world's first 600MW supercritical circulating fluidized bed unit already under construction. Compared with pulverized-coal fired boiler, emission of SO2 and NOx is reduced by 50%, CO2 by 10% and 10% coal can be saved.
Coal gasification	250MW demonstration plant under construction in Tianjin and to be finished by

combined cycle power generation	2011. This project includes pollutant recycling and carbon capture to realize the goal of zero emission of air pollutant and CO_2.
Coal gasification	Independently-developed two-stage dry pulverized coal pressurized gasification technology and equipments are already used in Tianjin IGCC project and are exported to the U.S.
Gas produced from coal	5 projects under construction or to be constructed, with total annual production capacity of 19 billion cubic meters. The project being constructed at Chifeng of Inner Mongolia has an annual production capacity of 4 billion cubic meters and will be able to supply gas to Beijing in 2012. Compared with other coal utilization technologies, coal-derived gas consumes the least water and has the least CO_2 emission in its production process.

Source: China Coal Processing & Utilization Association, Coal Industry Clean Coal Technology Engineering Research Center, CEC, CPCIF

Table 2-9: China's Renewable Energy Development and Utilization Amount in Global Proportion (2010)

	Development and utilization amount	Accounting for global proportion/%	Top 3 in the world
Hydropower	721.02TWh	21	China, Canada, Brazil
Wind power generation installed capacity	41827MW	18	China, U.S, Germany
Photovoltaic cell output	8GW	50	China's Mainland, Taiwan, U.S
Solar heater inventory	170 million m3□ collector area□	60	China, Turkey, Japan
Direct geothermic utilization	8898MW	18	China, U.S, Sweden
Methane output	16.4 billion m3	40	China, U.S, Germany

Notes: see endnote #84

Sources: National Bureau of Statistics, National Energy Administration, Ministry of Science and Technology, Ministry of Land and Resources, China Renewable Energy Society, World Wind Energy Association, International Geothermal Association, Renewable Global Status Report; IEA, Global primary energy structure 2009; BP statistical Review of World Energy, June 2010.

The energy efficiency of some leading enterprises in such industries as thermal power, concrete and electrolytic aluminum has reached world advanced level. See Table 2-10.

Table 2-10 - Energy Consumption Comparison of Several Highly Energy-consuming Products with International Level

	2005			2010		
	China	International advanced level	gap	China	International advanced level	gap
coal consumption of thermal power supply/gce/kWh	370	314	+17.8	335	310	+8.1
comparable energy consumption of steel/kgce/t	732	616	+18.8	717	610	+17.5
Ac power consumption of electrolytic aluminum /kWh/t	14575	12900	+13.0	13979	12900	+8.4
comprehensive energy consumption of concrete/kgce/t	167	127	+31.5	126	118	+6.8
Comprehensive energy consumption of ethylene /kgce/t	1073	629	+70.6	950	629	+51.0

Notes: see endnote #85

Sources: National Bureau of Statistics, Ministry of Industry and Information, China Electricity Council, China Iron and Steel Industry Association, China Nonferrous Metals Industry Association, Chinese Building Materials Industry Association, China National Chemical Energy Saving Technology Association, Institute of Energy Economics Japan, Handbook of Energy and Economic Statistics in Japan (2010 Edition), Iron and steel Institute of Japan, Korea Iron and Steel Association, Japan Cement Association

2. The Majority of the Enterprises in High Energy-Consuming Industries are Small Ones.

Small enterprises account for a large proportion in China's high energy-consuming industries, calculating in production. With backward production methods, technologies, facilities and management, many of the small enterprises consume energy 30%-60% more than large ones per unit of products, which is the main reason for the higher energy consumption of some Chinese products than the international average. For instance, in 2009, the average processing capacity of China's oil refining companies was only 2.6 Mt, compared with 22.5 Mt of the counterparts in South Korea. The comprehensive energy consumption of China's oil refining industry was 22 % more than the advanced international level. The brick and tile plants totaled 90,000, with comprehensive energy consumption doubling the international advanced level. The number of paper-making factories above designated size (before 2011 when a new standard of RMB 20 million was adopted, the enterprises should have annual revenue of above RMB 5 million from main businesses) in China reached 5,700 (in 2006, there was a total number of 30,000 factories in this industry), the average annual production of which was less than 1/10 of that in foreign countries.

The comprehensive energy consumption of paper-making factories which supply pulp by themselves was nearly 80% higher than the advanced international level.

3. More Efforts to eliminate Backward Production Capacities.

With strict directive measures, the Chinese government has achieved great results in phasing out backward production capacities in high energy-consuming industries, contributing a lot to energy conservation and emission reduction in the industry sector. For instance, the coal consumption of thermal power units (with a size of or smaller than 100 MW), which have been phased out, was 30%-50% more than those with a size above 300MW; the energy consumption of blast furnaces (with a volume of or smaller than 300 m3) was over 20% higher than those larger than 1000 m3. The heat consumption of small shaft kilns is 40% higher than that of large NSP cement production lines. See Table 2-11 to find backward production capacities in high energy-consuming industries phased out during the “11th Five-Year Plan” period.

Table 2-11: Production Capacities eliminated in the Industry Sector from 2006 to 2010

	Production of 2010	Utilization rate of the production capacities in 2010/%	Production capacities eliminated from 2006 to 2010
Raw coal	3240Mt	90	450Mt□9000 mine wells
Coke	387.6Mt	83	10.38Mt
Coal power	3416.6TWh	5031 hours annually	72.1GW
Iron smelting	590.22Mt	88	111.7Mt
Steel smelting	626.96Mt	82	68.6Mt
Iron alloy	24.36Mt	72	6.63Mt
Cement	1876.6Mt	72	403Mt
Glass sheets	662.6 million weight case	76	152 million weight case
Electrolytic aluminum	15.65Mt	74	0.8Mt
Calcium carbide	14.30Mt	60	4.0
Paper-making	100.4Mt	90	10.3

Source: Ministry of Industry and Information Technology, National Bureau of Statistics, China National Coal Association, China Coking Industry Association, China Electricity Council, China Building Material Industry Association, China Paper Association

2.2 A strong foundation

2.2.1 It's hard to change China's coal-based energy structure

China is among a small number of countries which rely on coal as a major energy source. In 2009, coal accounted for 70.3% of the total primary energy consumption in China, while the proportion in US was 22.8%, in Japan 23.4%, in EU 25.5% and the world average 23.7% as referred to in Table 2-12.

Table 2-12: Consumption and Structure of Primary Energy around the World (2009)

	Consumption of primary energy/Mtoe	Consumption structure/%				
		oil	natural gas	coal	nuclear power	hydro-power
US	2182.0	38.6	27.0	22.8	8.7	2.9
China	2177.0	18.6	3.7	70.6	0.7	6.4
Russia	635.3	19.7	55.2	13.0	5.8	6.3
India	468.9	31.7	10.0	52.4	0.8	5.1
Japan	463.9	42.6	17.0	23.4	13.4	3.6
Canada	319.2	30.4	26.7	8.3	6.3	28.3
Germany	289.8	39.3	24.2	24.5	10.5	1.4
France	241.9	36.1	15.9	4.2	38.4	5.4
South Korea	237.5	43.9	12.8	28.9	14.1	0.3
Brazil	225.7	46.2	8.1	5.2	1.3	39.2
Iran	204.8	40.8	57.9	0.7	—	0.6
UK	198.9	37.4	39.2	14.9	7.9	0.6
Saudi Arabia	191.5	63.6	36.4	—	—	—
Italy	163.4	45.9	39.5	8.2	—	6.4
Mexico	163.2	52.4	38.4	4.2	1.3	3.7
Spain	132.6	55.0	23.4	8.0	9.0	4.6
EU(27 countries)	1622.6	41.3	25.5	16.1	12.5	4.6
OECD	5217.1	39.7	25.0	19.9	9.7	5.7
The world	11164.3	34.8	23.7	29.4	5.5	6.6

Note: For nuclear power and hydro-power, we use 38%, the conversion efficiency of coal power plants, to convert thermal equivalent.

Source: BP Statistical Review of World Energy, June 2010

Compared with oil and natural gas, coal has lower utilization efficiency but higher CO2 emission level. The utilization efficiency of coal was 23% and 30% lower than that of oil and natural gas, while its CO2 emission is 130% and 170% as that of the latter two respectively by calculating in unit heating value.

Due to a large proportion of coal in primary energy of China's energy mix, China's CO2 emission level is much higher than the world average. In 2010, China emitted 7879MT of CO2.

In 2010, CO2 emitted from coal combustion in China was 82.5% of its total emission, or 48.2% of the world's total emission from coal combustion, which is shown in Table 2-13.

China is the largest coal producer and consumer. In 2010, its production was 3,240 Mt, 44.5% of the world's total. Its consumption was 32.92Mt, among which 53.4%, 13.9%, 15.3% and 6.0 % went to power and heat generation, steel, construction material and chemical industries respectively. China's current coal consumption far exceeds the estimated. Just a few years ago, the coal demand of 2020 was anticipated to be 3000Mt, but now the consumption has reached this level 10 years in advance. With the continuous growth of the demand from high coal-consuming products, it's inevitable for China's coal demand to increase in a large scale. Regarding China's energy resource supply (in 2008, coal accounted for 96.5% of the remaining recoverable reserves of fossil fuels), coal price advantage, the development of clean coal technologies and supportive infrastructure conditions, it's difficult to change China's coal-based energy mix. According to many anticipation studies of energy demands, to the year of 2050, despite the decrease of coal's proportion, it still will be the largest energy source for China.

2.2.2 Emissions from key industries

The CO2 emission from China's industry sector took up an exceptionally high proportion in the total of terminal energy consumption. The CO2 emission from Chinese manufacturing industry accounted for 33% of the total emission in 2008, and the figure was only 11% in America.

Table 2-13: Constitution of CO2 emission in different categories and industries in different countries (2008) Unit: %

	China	US	Japan	World
Emission of different categories %				
Coal	83	37	36	43
Petroleum	14	40	46	37
Natural gas	3	23	18	20
Total	100	100	100	100
Emission of different industries %				
Power generation and heat supply	48	43	41	41
Other energy industries	4	5	4	5
Manufacturing industry and construction industry	33	11	21	20
Transportation	7	30	20	23
Other industries	8	11	14	11
	100	100	100	100

Source IEA 2010.

The CO2 emission in China differs from region to region, which is closely related to the layout of heavy chemical industries, as referred to in Table **2-14**. In 2009, Inner Mongolia, Ningxia, Shanghai, Shanxi and Liaoning, all China's major heavy chemical bases, were the top 5 emitters calculated by per capita emission. In Inner Mongolia, the industrial output value was 60% of its GDP, and in Shanghai, the proportion was 51%. In Shanxi, the output value of heavy chemical industries accounted for 80% of its total industrial output value. That year, Shanghai's per capita emission reached 12.7t, the top one among cities with more than a 10 million population around the world, nearly doubling that of New York, Tokyo and London. In 2008, per capita emission in New York was 6.4t (Michael Bloomberg), in Tokyo 6.3t (keisuke Hanaki), and in London 6.2t (Daved Dodman).

Table 2-14: Energy consumption and Carbon Emission of Regions in China (2009)

	Energy consumption per unit of GDP/tce/RMB 10,000	Energy consumption per unit of industrial added value/tce/ RMB10,000	Per capita GDP/RMB	per capita energy consumption/kgce	per capita CO2 emission/t-CO2
Beijing	0.606	0.909	70452	3474	8164
Tianjin	0.836	0.911	62574	4132	9710
Hebei	1.640	2.999	24581	3614	8493
Shanxi	2.364	4.550	21522	4545	10681
Inner Mongolia	2.009	3.557	40282	6335	14887
Liaoning	1.439	2.257	35239	4425	10399
Jilin	1.209	1.621	26595	2809	6601
Heilongjiang	1.214	1.382	22447	3834	9010
Shanghai	0.727	0.957	78989	5397	12683
Jiangsu	0.761	1.107	44744	3069	7217
Zhejiang	0.741	1.123	44641	3005	7062
Anhui	1.017	2.100	16408	1451	3410
Fujian	0.811	1.150	33840	2458	5988
Jiangxi	0.880	1.674	17335	3112	7313
Shandong	1.072	1.543	35894	3423	8044
Henan	1.156	2.708	20597	2082	4893
Hubei	1.230	2.350	22677	2397	5633
Hunan	1.202	1.570	20428	2081	4890
Guangdong	0.684	0.809	41166	2558	6011
Guangxi	1.057	2.235	16045	1457	3424
Hainan	0.850	2.613	19254	1427	3353
Chongqing	1.181	1.854	22920	2459	5779
Sichuan	1.338	2.249	17339	1994	4686
Guizhou	2.348	4.320	10309	1992	4681
Yunnan	1.495	2.739	13539	1757	4129
Shaanxi	1.172	1.367	21688	2133	5013
Gansu	1.864	3.530	12872	2080	4888
Qinghai	2.689	2.936	19454	4215	9905
Ningxia	3.454	6.509	21777	5421	12739
Xinjiang	1.934	3.095	19942	3486	8192

Note: 1. The regional CO2 emission was calculated according to national emission factor.

2. The national per capita GDP, energy consumption and CO2emission were RMB 25,575, 2297kgce and 5365t.

Source: National Bureau of Statistics, National Development and Reform Commission, National Energy Bureau

2.2.3 Despite substantial achievements in energy consumption, the waste of energy is still very serious.

1. The accelerated progress of energy-saving technologies

In the past 5 years, backward energy-saving technologies have been obviously improved, thanks to market competition, promotion of technological level and production capacities in energy facility manufacturing industry, guidance and encouragement from government policies, as well as the wide spread of high energy-efficient facilities and methods in high energy-consuming industries.

From 2005 to 2010, the proportion of thermal power units larger than 300 MW has increased from 47% to 69%; for the penetration rate of coke dry quenching (CDQ) technology in steel enterprises, from 35% to 83%; for production of NSP cement production lines, from 40% to 80%; and for production of ionic membrane caustic soda, from 34% to 76%, as referred to in Table 2-15:.

Table 2-15: Progress in Energy-Saving Technologies in China's High Energy-Consuming Industries

	2000	2005	2010	Energy-saving results
Electric power				
proportion of thermal power units larger than300MW/%	43	47	69	The coal consumption of units at 100MW is 30%-50% higher than that of units at 300MW.
Steel				
proportion of production capacity of blast furnaces with a volume more than 1000 m3 /%		21	34	The energy consumption of blast furnaces with a 300m3 volumn is 20% more than that of blast furnaces with a 1000 m3 volumn.
penetration rate of CDQ technology/%	6	35	83	For every 1 million tons of red coke Handled with CDQ technology, 100,000 tce of energy could be saved.
penetration rate of TRT facilities/%	50	81	100	With TRT facilities, power generation per ton of iron could reach 30kWh
Electrolytic aluminum				
proportion of production by large pre-baked cells/%	52	80	90	Pre-baked cells larger than 160kA consume electricity 9% less than self-baked cells.
Chemical industry				
proportion of caustic soda production by ionic	25	34	76	For the production of every ton of caustic soda, ionic membrane method consumes electricity

membrane method/%				123 kWh less than diaphragm method.
Construction materials				
proportion of cement production by NSP production lines/%	12	40	80	The heat consumption of NSP production lines is 40% less than shaft kilns.
bulk rate of cement/%	28	39	48	For every 100 million tons of cement, the bulk method could save 3.3 millions m3 of wood and avoid 4.5% damages of paper bags, in this way saving 2.37 million tce of energy
proportion of glass sheet production by float method/%	57	79	86	The comprehensive energy consumption of float method is 16% less than vertical drawing method
proportion of new wall material production/%	28	40	58	The energy consumption of producing new wall materials is 40% less than traditional ones.

Note: The penetration rate of CDQ technology means the proportion of the amount of coke handled with CDQ technology to the total; the penetration rate of TRT facilities means the proportion of blast furnaces larger than 1000 m3 with TRT facilities to the total number of blast furnaces larger than 1000 m3.

Source: China Electricity Council, China Iron and Steel Association, China Coking Industry Association, China Nonferrous Meals Industry Association, China Building Material Industry Association, China Chemical Energy Conservation Technology Association

2. Substantial achievements in technological energy-conservation

Thanks to the promotion of energy-saving technologies and phasing out of many backward production capacities, the energy consumption of high energy-consuming products have been reduced obviously. Compared with that of 2005, in 2010, the comprehensive energy consumptions of coal power, cement, ammonia synthesis and chemical fibers was down by 9.5%, 24.5, 17.3% and 30.6% respectively.

During the “11th Five-Year Plan” period, China’s industry sector has saved 339Mtce of energy by using new technologies, contributing 54% to the total energy conservation. Among this, 13 products in 7 industries have saved 172Mtce of energy by using new technologies. Since these 13 products consume 70% energy in the manufacturing industry, the total energy consumption reduced in this industry could be 246Mtce. The thermal power industry has saved 93Mtce of energy.

Table 2-16: Energy Conservation of China’s Manufacturing Industry uring the “11th Five-Year Plan” Period

	Product energy consumption			Production of 2010	Energy conservation during the “11th Five-Year Plan” Period /Mtce
	unit	2005	2010		
Steel	kgce/t	760	701	626.96	37.00
Electrolytic	kWh/t	14575	13979	15.65	3.26

aluminum					
Copper	kgce/t	780	500	4.57	1.28
Cement	kgce/t	167	126	1876.61	76.94
Glass sheets	kgce/weight case	22.0	16.3	662.61	3.78
Oil refining	kgce/t	114	100	423.0	5.92
Coking	kgce/t	156	117	388.0	15.13
Ethylene	kgce/t	1073	950	14.17	1.74
Ammonia synthesis	kgce/t	1700	1464	51.50	12.15
Caustic soda	kgce/t	1297	1006	20.87	6.07
Soda ash	kgce/t	396	317	20.27	1.60
Calcium carbide	kWh/t	3450	3340	14.30	0.55
Chemical fibers	kgce/t	743	517	29.73	6.72
Total					172.14

Notes: see endnote # 86

Source: National Bureau of Statistics, Ministry of Industry and Information Technology, China Chemical Energy Conservation Technology Association, China Chemical Fibers Association; Wang Qingyi, "the Assessment of China's Energy Efficiency", Energy Conservation and Environment Protection, 2011, No.1, 38-42.

3. A large amount of energy is wasted to generate inefficient GDP

China has serious direct and indirect energy waste, "creating" many top ones in the world. In some areas, the wasted energy is far more than the conserved amount by implementing policies and measures.

i) Construction of Residential Buildings

China has the lowest utilization rate of residential buildings in the world. According to the estimate by Social Policy Research Center of Chinese Academy of Social Science, in 2010, the housing vacancy rate in China's urban area was about 25%, equivalent to more than 30 million housing units. The housing vacancy rate of developed nations is controlled to below 10%. According to this standard, 15% of the residential buildings or 2 billion □ are idle. Since it takes 50 kg of steel and 200 kg of cement to build each □ of residential buildings, it equals to wasting 153 Mtce of energy, calculated by comprehensive energy consumption of steel and cement production. In contrast, in the northern part of China, 182 million □ of existing residential buildings were upgraded to save only 2.0 Mtce of energy.

ii) Urban construction

According to the estimate by Mr. Li Kaifa, an economist, of the GDP generated by large demolition and construction projects in first-tier cities, over 10% was just bubbles (Oriental Outlook Weekly, 2010, No. 23). In 2009, the GDP of 11 cities, which have over RMB 400 billion of GDP, totaled RMB 8,075 billion, a 24% of the total of the whole country. Calculated by 10%, the GDP bubbles reach to RMB 807.5 billion. For every RMB 10, 000 of GDP, it consumes 0.20t of steel and 0.48t of cement. Therefore, in 2009, large demolition and construction projects wasted at least 55Mtce of energy.

iii) Government Organs

Chinese government agencies also waste a lot of energy, in particular office buildings and government vehicles. The per capita office building area in China is No. 1 around the world (Li Jinhua, 2009-09), far more than that of the provision in Standard of Per Capita Office Building Area in Party and State Organs adopted in 1999. In 2009, the per capita electricity consumption of the 5 million administrative staff in China was 4,720 kWh, 2.1 times as per capita daily electricity consumption in Japan. The total electricity consumption in administrative organs was 23.6TWh, equivalent to 8Mtce. If we use the electricity consumption standard of Japanese daily life, then the administrative organs in China at least waste one half of the power, equal to 4Mtce every year.

iv) Food

China's terminal consumption wastes 50 Mt of food annually (Zheng Chuguang, 05/03/2010), that is, 9.4% of the 2009 food production. Based on the diesel, electricity and fertilizer consumption of agricultural production and irrigation, it takes 0.25 tce of energy to produce 1t of food. Therefore, the waste of 50Mt of food equals to a waste of 12.5Mtce of energy.

The energy waste and the inefficient GDP may explain the following situation. At present, despite the fact that China's physical energy efficiency is only 2-3% lower than that of US, and its power generation efficiency even surpass that of US, its energy consumption per unit of GDP is still 3.6 times as that of the latter, which even calculated by purchasing power parity is much higher.

2.2.4 Low-carbon technologies show the potential of carbon reduction.

The low-carbon technologies in the industry sector include: energy production and utilization technologies, low-carbon circle economy, new material technologies, as well as carbon capture and storage technologies. With active efforts, China has marked great achievements in developing and applying low-carbon technologies, demonstrating great carbon-reduction potentials. Table 2-17 shows China's low-carbon technology cases.

Table 2-17: China's Low-Carbon Technology Cases

Low-carbon technology	Carbon-reduction effects
1. coal preparation	With this technology, 70% of ash and 60% of pyritic sulfur could be removed from coals. Using coals disposed by this method, at least 10% of coals could be saved. In 2010, by handling 1,650 Mt of coals, China reduced 160 Mt of coal consumption and 320 Mt of CO2 emissions. (China Coal Processing and

	Utilization Association)
2. green coal power	China's Huaneng Green Coal Power Project, which includes Integrated Gasification Combined Cycle (IGCC), pollutant recycle, as well as carbon separation, utilization and storage, takes a leading role in clean coal technologies around the whole world. In July of 2009, construction of the project was launched in the Coastal Industrial Zone of Tianjin. In the same year, the Two-stage Dry-Feed Pressurized Gasification Technology, which was developed independently by this project, was introduced into Future Fuels Company in Pennsylvania of US. This project, invested at RMB 2.1 billion, has power units with a capacity of 205 MW. Expected to be completed into operation in 2011, it could realize a 99% of de-sulfur rate and nearly zero pollutants and CO2 emission (the green coal power company).
3. smart grid	With advanced communication, information and control technologies, the smart grid could improve power grids to achieve the objectives of IT application, digitalization, automation and interaction. In this way, China could optimize the allocation of power grid resources, improve the reliability of power supply, enhance the power quality and solve the problem to integrate power from renewable energies. Through fine management of demands, it could also raise the terminal power utilization rate. Still in pilot, China's smart grids are expected to be finished in 2020, when annually 400Mtce of energy could be saved and 1100Mt of CO2 emission reduced. (Jiang Liping, 2010)
4. recycling process of iron and steel production	The new generation of recycling process of iron and steel production integrate the advanced technologies of iron and steel production, energy conversion and waste utilization. By establishing a strategic alliance of this new technology, 6 large iron and steel enterprises in China aim to produce 100 Mt of high quality steel and generate 210 TWh of electricity every year, while cutting energy consumption per ton of steel to below 640kgce and reducing 100Mt of CO2 emission. At the end of 2010, the Shougang Caofeidian Iron and Steel Company was set up, with an annual steel output of 9.7 Mt. The newly-formed Shandong Iron and Steel Group plans to build itself into a world-class iron and steel company with an annual output of 50Mt, by using this new technology. (Science and Technology Daily, 07/04/2010; Shougang Caofeidian Iron and Steel Plant, 17/01/2010)
5. new wall materials	New wall materials refer to the ones which replace traditional bricks, including over 20 types in 3 categories such as hollow bricks, aerated concrete blocks and other fired hollow products. This also includes fired products made from industrial waste residue (coal gangue, coal ash, and other waste residue) and silt (sediment) in rivers or lakes. Polystyrene foam boards, rock wool boards, glass wool boards and gypsum boards also fall into this category. Compared with traditional bricks, the lighter new wall materials consume less energy but have better quality and could speed up the construction process. Furthermore, it could avoid the excessive use of earth. The new wall materials consume energy 40% less than traditional bricks during production and 30% less for heating when applied to buildings. In 2010, new wall materials accounted for 60% of the total amount.
6. building houses by assembling technologies	It could save materials, energy and land to assemble buildings with pre-made structures. Such buildings are also resistant to earthquakes and environment-friendly, nearly without any construction waste during assembly. Currently, China has mature technologies to assemble steel structures, high-strength prestressed concrete prefabricated units and light building materials into buildings. Compared with traditional building methods, it only takes 20% of time, while saving 30% of materials, 70% of energy and 20% of land. The Industrialization rate of residential housing construction in Europe and the US exceeds 60%, the rate is 70% in Japan and about 20% in China, and it is estimated to be 40% in China by 2015.(Zhu Hengjie, 26/03/2011, Hu Baosen,

	03/05/2011).
7. chemical industry zone	By building chemical industry zones, China could integrate materials, medium products, side-products and waste, so as to maximize the utilization of resources. China has set up more than 60 chemical industry zones. For instance, the Shanghai Chemical Industry Zone has an energy consumption of 1.2 tce and water consumption of 33t per RMB 10,000 output value, only 1/2 and 1/5 of the industrial average respectively. In this way, the investment could nearly be halved. (China Petro and Chemical Industry Association)
8. recycling of nonferrous metals	Recycle waste copper to produce secondary copper. Pure waste copper could be recycled in induction furnaces, and mixed waste copper in reverberatory smelting furnaces with electrolysis refining process. The energy consumption per unit of secondary copper is only 55% of that for primary copper (which covers energy consumed in exploitation, ore dressing and smelting). The mixed waste aluminum could be recycled by smelting in single-chamber reverberatory furnaces. The energy consumption per unit of secondary aluminum is only 3.7% of that for primary aluminum. The outputs of secondary copper, lead and aluminum were 2.4million, 4 million and 1.35 million, respectively in China in 2010, and 17.2Mtce of energy is saved compared with primary metals.
9. integration of forest development and paper-making	It could accelerate the development of planted timber forests and is conducive to water conservation, energy conservation and collective waste treatment to integrate forest planting, operation, logging, pulp-making and paper-making. The COD emission of China's paper-making industry is 1/3 of that in the industry sector. Taking advantage of the integration system, Jindong Paper-making Company in Jiangsu province produces over 1 million tons of art paper, with water consumption of 10.7 m3 per ton of paper (only 18% of the national standard) and COD emission only 1/6 of the national standard. At the end of 2008, 30 pulp and paper making enterprises planted forests which were anticipated to cover 5 million hectors in 2010. (Gu Mingda, 10/03/2011) Each hector of forests could absorb and fix 150 tons of CO2.
10. carbon capture and storage	In 2008, in a capture trial, China Huaneng Gaobeidian Power Plant successfully captured 3000 tons of CO2, 0.75% of the amount generated. Experiments show that for a 300 MW power plant to capture every 1 Mt of CO2, the construction price will be increased from RMB 4000 /kW to RMB 8000 /kW. At the same time, the energy consumption will be up by 30% and power generation cost up by 20%-30%. In 2010, the CO2 capture project was finished in Shanghai Huaneng Shidongkou Plant, which could capture 100,000 tons of CO2 with 99.9% purity. For every one ton of CO2, it consumes 3.5J of heat and 90kWh of electricity. The Shengli Oil Field in China is also launching projects of CO2 capture, purification, oil displacement and storage. Currently, it injects 100 tons of CO2 into 4 wells, 50%-60% of which is stored underground and the rest 40%-50% will be back above ground. The upward CO2 is captured again to experience the whole process. After completion, this project will be the largest CCS project around the globe, capturing, utilizing and storing 1 Mt of CO2 every year at an estimated cost of RMB 230/ t-CO2. (Southern Weekly, 07/08/2009; GDCCSR Project Team, 08/2010; Research Institute of Sinopec Nanjing Chemical Plant, 2011)

Box 2-1: Shougang Caofeidian Iron and Steel Plant

At the end of 2010, with more than 2 years' efforts, Shougang Caofeidian Iron and Steel Plant was built with over 140 technologies of recycling process of iron and steel production, innovated independently and collectively. It has production capacities of 9.89 Mt of pig iron, 9.70Mt of steel and 9.05 Mt of steel materials. With a volume of 5,500 m3, No1 and No2 blast furnaces are the largest ones with the most advanced technologies within China, the coal injection ratio and blast furnace utilization coefficient of which have reached international standards. Facilities such as efficient large coke furnaces and 2250 cold rolled plate production lines are also with cutting-edge technologies. By recycling remaining heat, pressure, gas, waste water, solid waste and waste containing iron, this plant basically realizes zero emission. Besides the usage in iron smelting, steel smelting and steel rolling, the recycled coal gas from blast furnaces, revolving furnaces and coke furnaces can also be used to generate 5,500 GWh annually, contributing 94% of the power consumed by the plant itself. Steel slag could be used as raw materials of construction materials and blast furnace slag could be used in concrete mixed materials and cement production.

The new technologies in the manufacturing industry have great potentials for carbon reduction. For instance, the ironless PM motors independently developed by China could save 30% of power than traditional ones.

Box 2-2: Rare-earth Ironless PM Motor

The rare-earth ironless PM motor developed independently by Shenzhen Antuoshan Special Electric Machinery Company changes the structures of siliceous steel sheets and winding stators in the traditional motors. It has the following characteristics: axial magnetic field structure, special layout of winding units and molding method, ironless stators and rotators, and electronic intelligent frequency conversion technology. With the efficiency of 95%, this type of motor consumes energy 30% less than traditional ones. The smaller machine can also save 80% of steel materials and 50% of copper materials, compared with traditional ones. Without siliceous steel sheets and iron core, it is more reliable with a better insulation and resistant to the effect of water, moist and dust.

This new technology takes a leading role in the world. In 2010, China has built 3 production lines for bulk production. If 1/3 of newly-added motors go to this type, then China could save 50 TWh, 500,000 tons of siliceous steel sheets and 20,000 tons of copper every year. In 2011, the government, in the way of financial subsidies, will spread the application of 1770 MW of rare-earth ironless PM motors.

The ultra high-performance concrete, exhibited in the France Pavilion of Shanghai World Expo, is the patent product of France Lafarge Company. It uses reinforced steel fabrics rather than steel bars. Its pressure resistance intensity is 6-8 times as that of ordinary concrete, anti-fold intensity 10 times, and fire resistance 100 times. Besides, it also has better heat resistance. While guaranteeing certain intensity, it could be made into very thin products in different colors and shapes, just like plastics. To replace traditional reinforced concrete, the ultra high-performance concrete could save 30%-70% of cement, 15%-25% of steel materials, and 46% of energy, as well as reduce 53% of CO_2 emission. (Economic Daily News, 21/08/2010; France Lafarge Company, 2010). Lafarge has established a joint venture in China to produce ultra high-performance concrete.

Japan began to develop super steel, the intensity and service life of which double that of ordinary steel materials. This project was carried out in 3 stages. In the first one from 1997 to 2001, the Japanese government earmarked 12 billion yen. In the second one from 2002 to 2007, 8 billion yen of investment came from enterprises. In the future 30 years, it is possible for Japan to produce iron and steel by only using steel craps rather than imported iron ore. (Economic Information Daily, 25/06/2010)

2.3 Overcoming challenges

2.3.1 Transforming high carbon industry.

1. China's High-carbon Industrialization.

Compared with post-industrial developed countries, the current Industrialization in China is high-carbon. According to IEA data, China's CO2 emission in manufacturing and construction industries accounted for 37% of the world's total in 2008, and equivalent to the total emission in industry and building industry of OECD.

As mentioned above, China is being through the fast-growing period of urbanization and Industrialization. The heavy Industrialization will last at least 10 years.

2. High Reliance of China's Industry on Coal.

China's industry is highly dependent on coal. According to IEA data, coal for industry went to 387Mtoe in 2008, or 59% of the total energy consumption in the industry sector, 60% of the total global coal consumption or 2.5 times as much as that of OECD. Only 110Mtoe coal was consumed by OECD, accounting for 13% of the global total energy consumption in industry sector.(IEA, 2010)

In China, future rigid demand for coal in manufacturing industry especially steel, building materials and chemical will inevitably and significantly increase. Coke (or coal injection) is still needed in iron-smelting. Neither oil nor gas can replace coal in cement especially brick production. Approximately 100Mt coal is consumed per year for brick production while in US only 10% of brick factories use coal. In 2006, 64% of China's synthetic ammonia was coal, up to 77% in 2009 with oil replaced by coal due to its rising price.

Carbon lock-in generated from the over dependence on carbon is the greatest challenge for low-carbon development.

Box 2-3: Carbon Lock-in and Low-Carbon development

The concept of "Carbon lock-in" was first proposed by Spanish scholar Gregory C. Unruh at the turn of the century, explaining why the diffusion of climate-friendly technologies is so difficult. Technologies in fossil energy system have been dominant and prevalent since the Industrial Revolution. Together with politics, economy and society, a "Techno-Institutional Complex" formed, preparing for widespread commercialization. The consequent internal inertia leads to technological lock-in and path dependency, unfavorable to free-carbon or low-carbon development. Rooted in society, technologies are strengthened by traditional departments such as school, industry and engineers association via standards, education and training.

Low-carbon development can gradually get rid of "carbon lock-in", the core of which is to transfer the pattern of economic growth. The concept of "carbon lock-in" in turn betters the understanding of "low-carbon economy" and "low-carbon development". As only one of the dimensions of CO2 emission reduction and environmental effects, carbon reducing is different from low-carbon economy. China's current extensive economic growth patterned on that of developed countries must be transferred to new path of Industrialization based on low-carbon development. (Xie Laihui, 2009)

3. Reliance of China's Manufacturing Industry on International Market.

China's manufacturing industry is highly dependent on international market. According to several studies (IEA, 2008; Weter et al; Qi Ye, etc, 2008; Yao Yufang, etc, 2009), CO2 emission in net exports is approximately 30% of that of the country, which will not significantly drop in the next 20 years.

2.3.2 The Weak Foundation of Technology Innovation.

Since China put forward the development strategy to build an innovative country in 2005, the innovation ability in the industry sector has been dramatically enhanced. R&D professionals in large and medium-sized enterprises have increased from 0.438 million to 1.306 million by 2009; R&D expenditure has increased from RMB 95.44 billion to RMB 321.16 billion (Table 2-18).

Table 2-18: R&D expenditure in national large and medium-sized enterprises in energy and energy-intensive industries (2009) Units: RMB 100 million

Total amount of national large and medium-sized enterprises	3211.6
Coal mining and washing	93.0
Petroleum and natural gas exploitation	62.4
Petroleum Refining, Coking and Nuclear Fuel Processing	33.8
Production and Distribution of Electric Power and Heat Power	29.4
Steel	305.4
Non-ferrous metal ores	97.4
Building materials	59.0
Chemical industry	197.3
Chemical fiber	32.4
Food, beverage and tobacco	83.6
Textile wearing	82.1
Paper and paper products	32.0
Manufacture of transport equipment	460.0
Manufacture of communication equipment, computers and other electronic equipment	549.6
Manufacture of general purpose and special purpose machinery	407.8

Source: National Bureau of Statistics

However, compared with developed countries, China still has a long way to go. In 2008, R&D expenditure only contributed to 0.84% of sales revenue in large and medium-sized enterprises while the proportion in developed countries was over 5%. Take electric power enterprises as an example, China's R&D expenditure in 2008 was 0.38 billion dollars, IEA 24 billion (2006 data, IEA, 2008); as for perineum and natural gas enterprises, the R&D expenditures were respectively 2.6 and 10 billion dollars (10 largest enterprises in IEA); in industrial equipment manufacturing enterprises, the figures were 4.7 and 15 billion dollars (8 largest enterprises in IEA:

Siemens, GE, Mitsubishi Heavy Industries, ABB, Alston, United Technologies, Caterpillar and IHI).

The country's innovation ability is still weak. Only less than 1/4 of the large and medium-sized enterprises have R&D center, 0.0003% have own key technologies with independent intellectual property rights, and up to 98.6% haven't applied for patents (Ministry of Science and Technology, 2008). Technological innovation is almost accomplished by developed countries. R&D expenditures in IEA energy and related industries reached to 40-60 billion dollars, 4 to 6 times as much as government expenditures. Chinese enterprises are far away being innovation subjects.

Besides, the absorption and re-innovation ability remains to be improved. In 2008, compared with RMB 44.04 billion spent on technology importation, RMB 10.64 billion was on digestion and absorption, equivalent to 24% of the former. In Japan and Korea, the expenditures on absorption are usually 3-10 times more than introduction funds.

Weak innovation ability leads to high reliance on foreign technologies, up to 50% while in US and Japan it is only around 5%. Without core and key technologies, the high-tech equipment is basically dependent on imports.

Technology is of prime importance to build low-carbon industry. According to "2010 Human Development Report: Towards Decent Work in a Sustainable, Low Carbon World" released by UNDP in May 2010, to achieve low-carbon development, at least 60 backbone technologies are needed, among which 42 are still unavailable. At present, with RMB 1,000 billion on equipment per year, 60% needs to be imported, including 90% of optical fiber manufacturing equipment, 85% of chip making equipment, 80% of petrochemical plants and 70% of car manufacturing equipments, numerical control machines and textile machinery (Ministry of Industry and Information Technology, 2011-03-31). 120 billion dollars were spent on semiconductor chip imports, accounting for 80% of the total, 106.2 billion dollars more than the imports of crude oil and refined oil. (Zou Shichang, 2010-10)

2.3.3 Inadequate Market Mechanism.

The general principles of market are: market pricing, competition, free access for enterprises and privatization.

Accelerate the market-oriented reforms in energy industry.

Market pricing for energy products has huge potential for energy conservation. According to an IEA study, calculated as the difference between end-user price and market price or international market price reflecting all supply costs, China's average subsidy rate of energy consumption in 2005 was 11%. The rate of gas, diesel, kerosene oil, LPG, natural gas and coal respectively went to 5%, 13%, 3%, 18%, 45% and 17%. Subsidies here include both direct and indirect financial intervention. Allowances, tax credits, tax deduction and soft loans are direct ones while ceiling price, energy infrastructure and tax-free service are indirect. 14% of energy would be saved in case of removing subsidies. (IEA, World Energy Outlook 2006)

At present, state-owned enterprises still play a major role in China's energy industry. In 2009, the gross industrial output, total assets, and total profits of state-owned and state-holding enterprises respectively accounted for 79.9%, 94.6% and 75.4% of that of enterprises above designated size (coal mining and washing, petroleum and natural gas exploitation, petroleum refining and coking, production of heat power and electric power, production and distribution of fuel gas). Among them, petroleum and natural gas exploitation contributed to 96.1%, 96.4% and 97.6%, while the proportions in total industry sector were 28.4%, 47.8% and 29.7%. The petroleum and natural gas industry is a typical oligopoly in China, inevitably leading to low efficiency, hindering the technology advancement, harming the interests of consumers and even aggravating the inequality in distribution. Compared with foreign petroleum enterprises, the performance of China National Petroleum Corporation in 2008 was quite poor. The per capita crude oil production, per capita total income and per capita net profit of CNPC were only 5.5%, 2.0% and 1.1% of that of Exxon Mobil. (US Petroleum Intelligence Weekly, 2009-11-30)

Free access for enterprises is another important principle. However, in China's energy industry, due to excessive government intervention, obstacles for SMEs both in entering and exiting the market still remain.

Research shows that if China adheres to its current energy strategy, CO2 emission in 2020 and 2050 would respectively reach to 23.6 billion and 62.3 billion tons; in case of advancing commercialized reforms, the emission would be 11.8 billion and 31.1 billion, reduced by half. (Mao Yushi, Sheng Hong, etc, "The Impact of China's Marketization on Demand-Supply of Energy and CO2 Emission", 2009)

2.3.4 Imperfect Policies and Regulations.

In recent years, Chinese government has intensively advocated a series of laws, regulations and policy measures with unprecedented efforts. Amend "Energy Conservation Law". Promulgate "Circular Economy Promotion Law", "Regulations on Energy Conservation of Civil Buildings", "Regulations on Energy Conservation of Public Institutions" and so on. Apply a system of responsibility for achieving the goals set for energy conservation and a system for assessing. Eliminate backward production capacity in energy intensive industries. Accelerate the development of energy-saving technologies and industrial information system. Strengthen the service and monitoring of energy-saving technologies. Put forward reforms on energy prices. Introduce fiscal policies and economic incentives to motivate energy conservation. Promote energy-saving products. Mobilize popular participation and 17 state organs have jointly launched a nationwide campaign on energy conservation and emission reduction.

However, in April 2007 Premier Wen Jiabao pointed out that in energy conservation, the awareness, responsibility, implementation, policies, funds as well as coordination still remained to be improved. The problems and obstacles are as follows:

1. Slow reform in energy prices.

Now, most of China's energy prices are still influenced by government intervention. Without sound pricing mechanism, the oil price is only nominally with the international market. Moreover, vast subsidies for losses are offered to oil monopolies which have already earned huge super-profits (the net profits of three state-owned petroleum enterprises in 2010 reached to RMB 265.1 billion while the subsidies to SINOPEC in 2008 was RMB 50.3 billion). Despite the fact that coal pricing is already market-oriented, most external costs such as the excessively high circulation costs are not included, unfavorable for "Mechanism of Coal-Electricity Price Linkage". Take coal from Shanxi Datong as an example, the circulation cost equalled to 55-60% of ex-factory prices if the coal was carried to Shanghai and Guangzhou in 2010. China's average industrial electricity price in 2009 was RMB 0.586 /kWh, 25% higher than that of US while residential electricity price was 35% lower (Li Ying, 2010-12-16). Subsidies from local governments are given to electricity intensive sectors, up to RMB 15 billion in 2009. In spite of the certain effect of differential prices (enterprises in eliminated categories have to pay RMB 0.3 more per kWh), some enterprises build their self-owned power plants or utilize small hydropower to generate electricity, and some others transfer the higher costs to customers.

2. Imperfect fiscal and taxation policies.

China has implemented a series of fiscal and taxation policies to save energy, reduce emission, adjust structure, improve technologies and develop new energies. In view of climate changes, policies in mineral, water, agriculture and forestry should also be adopted. For the moment, performance of the policies is inferior due to the lack of financial investment and sound input mechanisms; both tax restraint and preferential policies are inadequate; energy saving production purchasing of government remains to be improved (Su Ming, 2011-01-28). The fiscal policy system suitable to low-carbon development is currently under study, carbon tax included.

3. Excessive Use of Administrative Measures

To achieve the goal of energy conservation, administrative means are overused. Fast returns are expected via simply setting quota for energy consumption, imposing energy audit in industrial fixed asset investment projects, creating barriers to entry, issuing instructions to eliminate backward production capacity as well as mandatory indicators of energy consumption decline per unit of GDP. However, regardless of cost effectiveness and market variations, these instructions and standards are inevitably rudimentary and arbitrary, bringing dramatic adverse effects. The reckless expansion of energy-intensive industries has not been effectively curbed. “High standards, arbitrary directions and fraud” in “era of great leap”, more chances for power rent-seeking, and unemployment generated from the closure of enterprises have to be noticed. In some areas, electricity and even heating are cut off to achieve the goal of energy conservation; hence enterprises have to utilize diesel oil to generate power, costing more.

Box 2-4: Unemployment and the closure of small power plants

Enormous social costs have to be paid in the transformation to low-carbon economy, unemployment generated from the elimination of backward production capacity included. According to the research of National Development and Reform Commission and China Power Investment Corporation, 62 workers need to be resettled in average when shutting down every 10MW small thermal power units. By the end of 2010, 27.1 GW have been closed, bringing approximately 0.45 million workers laid off. New larger generation units and desulfurization units can indeed create some jobs, but the effect is quite limited. For example, a power company in Shanxi Province shut down 15 small units, 800 MW in total, 3,600 workers out of job; 2 units are newly built, 600 MW each, with only 380 workers resettled.

4. Energy conservation by SMEs

Currently, 99% of the enterprises in China are small and medium-sized enterprises. In the industrial sector, their output value accounts for 60% of the total. The amount of energy consumption is nearly half of that of the whole industrial sector and energy consumption per unit product is 30% higher than that of large enterprises. In terms of energy conservation, SMEs are faced with lots of difficulties such as financing, information, technology, talents, plus some policies of promoting energy conservation in the industry are designed for large state-owned enterprises, so the financial rewards in energy conservation are given to some enterprises that are undeserved or don’t need.

Compared with the US and Japan, their governments provide free energy audit for SMEs in energy conservation. For examples, USDOE provides assistance in the development of energy-saving and environmentally-friendly technologies for SMEs and transfer the scientific achievements of government research institutes without charge; in Japan, a treasury is designed to offer preferential loans for small and medium-sized enterprises in terms of energy conservation and they also provide assistance and tax exemption in technological development for SMEs. Those practices are worthy of our reference.

5. Barriers to private investment

In 2009, the output values of petroleum and natural gas exploration industry and electric power industry in state-owned enterprises account for 96.1% and 91.6% of the gross value of industrial output, respectively. Off-limits industry is the biggest barrier for the development of private enterprises. The implementation of "36 Items on Private Economy" in 2005 and "New 36 Items" in 2010 (Several Opinions of the State Council on Encouraging and Guiding the Healthy Development of Private Investment) have not yet achieved substantive progress so far. In contrast, monopoly is more rampant. High monopoly will result in inefficient operation and low competitiveness among the industry and harm the interest of consumers. In Brazil, the state-owned enterprises engaged in petroleum industry have opened their business to private and overseas enterprises since 1998. After 10 years, as the monopoly enterprises perked up, the output and reserves of petroleum have nearly doubled, becoming a net exporter from a net importer. (Yang Lei, 2010/1/15)

6. A statistical system of carbon emission monitoring needs to be established

A statistical system of carbon emission monitoring is still in the phases of research. Major problems:

i). The category of energy products is few and rough, which is much less than that in the emission list.

ii). "Factory method" is used to classify the production activities, which can not reflect energy consumption and emission of certain industries. For example, statistical data of energy consumption in building materials industry just includes the enterprises (nearly 60% of the total energy consumption) in the industry and statistical data of fuel consumption of highway transportation only includes fuel consumption of transportation departments (half of the total fuel consumption).

iii). Statistical data of energy consumption and emission monitoring of facilities is not completed.

3 LOW CARBON INDUSTRIALIZATION PATHWAYS

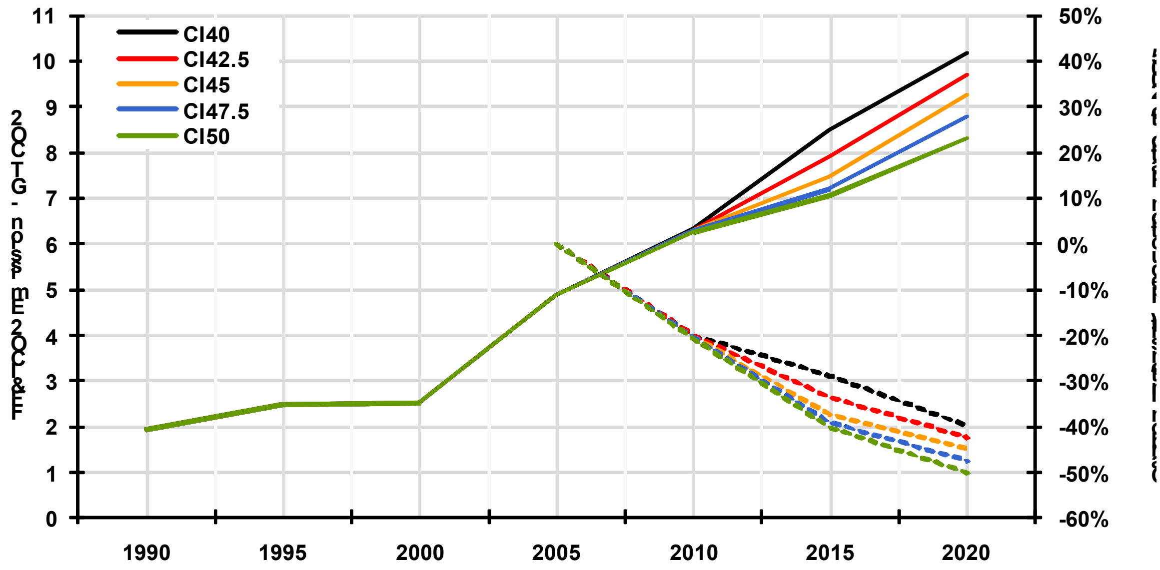
This chapter evaluates the role of low carbon Industrialization in the wider process of low carbon economic development; considers the primary paths of low carbon Industrialization and its potential in emission reduction; the major industrial sectors required to realize the low carbon Industrialization; and the role of innovation.

3.1 A key component of the low carbon economy

The method of scenario analysis was used in this part to analyze the impact of realizing 40% to 45% reduction of carbon intensity by the year 2020 on the economic and social development as well as the supply and demand of energy. The specific paths for low carbon Industrialization were also analyzed. Three situations were set in the article. The three situations were Situation CI-40 in which a reduction of 40% was realized in 2005, Situation CI-45 in which a reduction of 45% was realized in 2005 and Situation CI-50 in which a reduction of 50% was realized in 2005, respectively. The detailed description of the scenario can be found in the appendix.

The optimization approach to realize different carbon intensity policy targets is shown in Figure 3-1. Under the 40-45% reduction target of carbon intensity, fossil energy use and industrial process emission can be controlled at 75.-8.5 billion tons/year in 2015, and 9.0-10.0 billion tons/year in 2020.

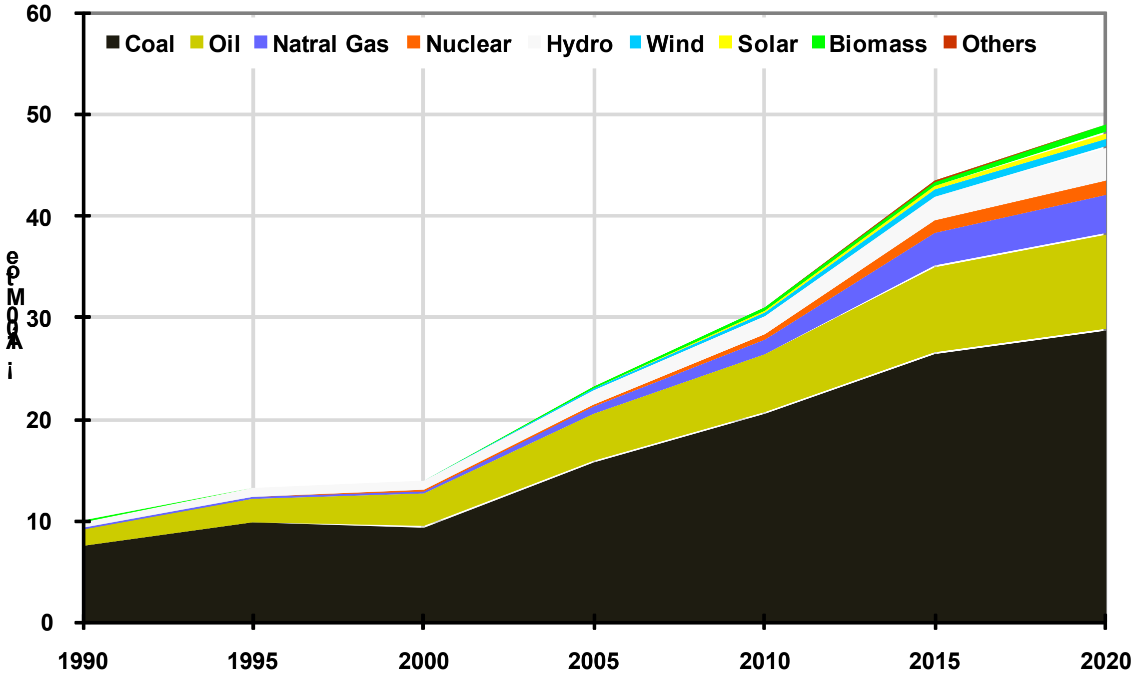
Figure 3-1: Impact of different carbon intensity policy targets on CO2 emissions



Source: LCIS Task Force analysis

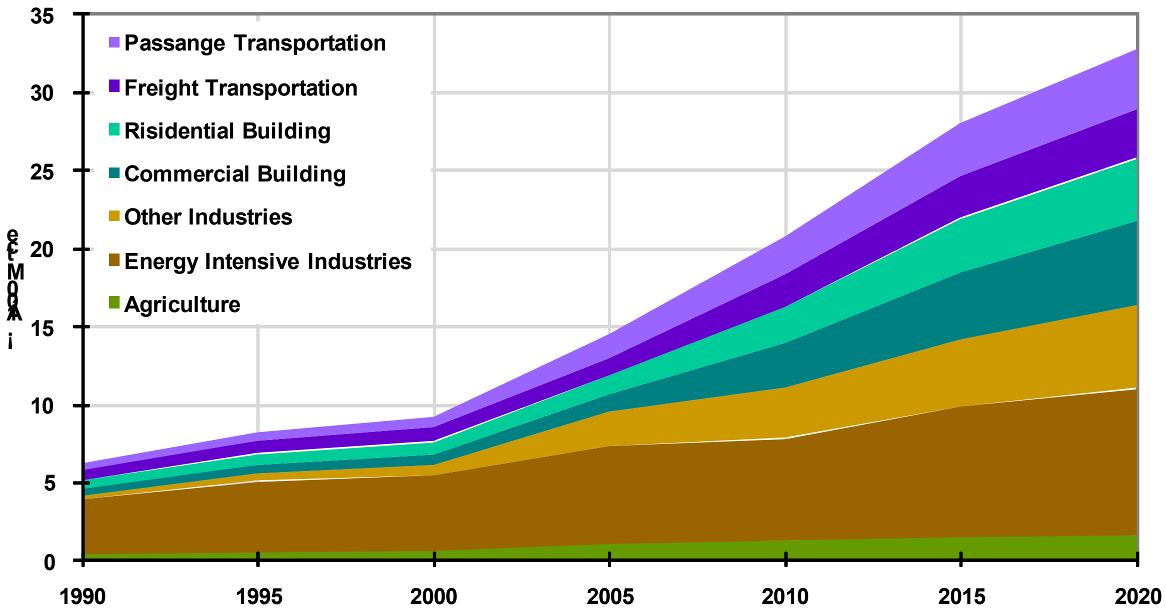
As shown in Figure 3-2, under different carbon intensity policy targets, the primary energy consumption is about 4.33 billion tons of standard coal, 4.01 billion tons of standard coal and 3.79 billion tons of standard coal in 2015, respectively; about 4.90 billion tons of standard coal, 4.67 billion tons of standard coal and 4.43 billion tons of standard coal in 2020, respectively. The terminal energy demand is about 2.81 billion tons of standard coal, 2.55 billion tons of standard coal and 2.38 billion tons of standard coal in 2015, respectively; about 3.29 billion tons of standard coal, 3.05 billion tons of standard coal and 2.82 billion tons of standard coal in 2020, respectively.

Figure 3-2: Primary energy consumption under CI40 scenario



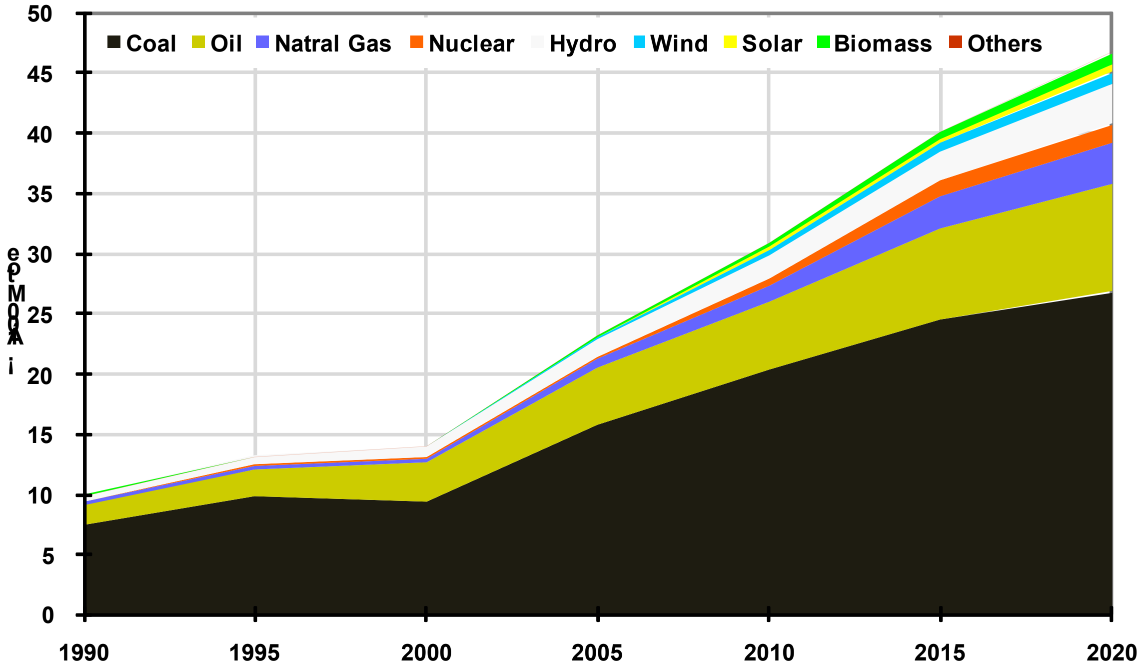
Source: LCIS Task Force analysis

Figure 3-3: Terminal energy demand under CI40 scenario



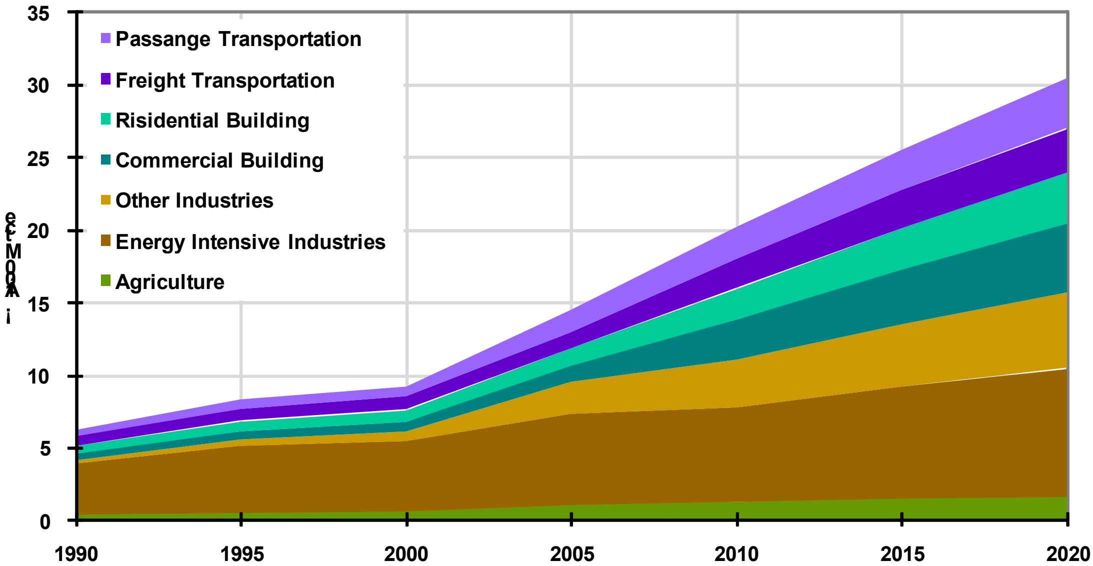
Source: LCIS Task Force analysis

Figure 3-4: Primary energy consumption under CI45 scenario



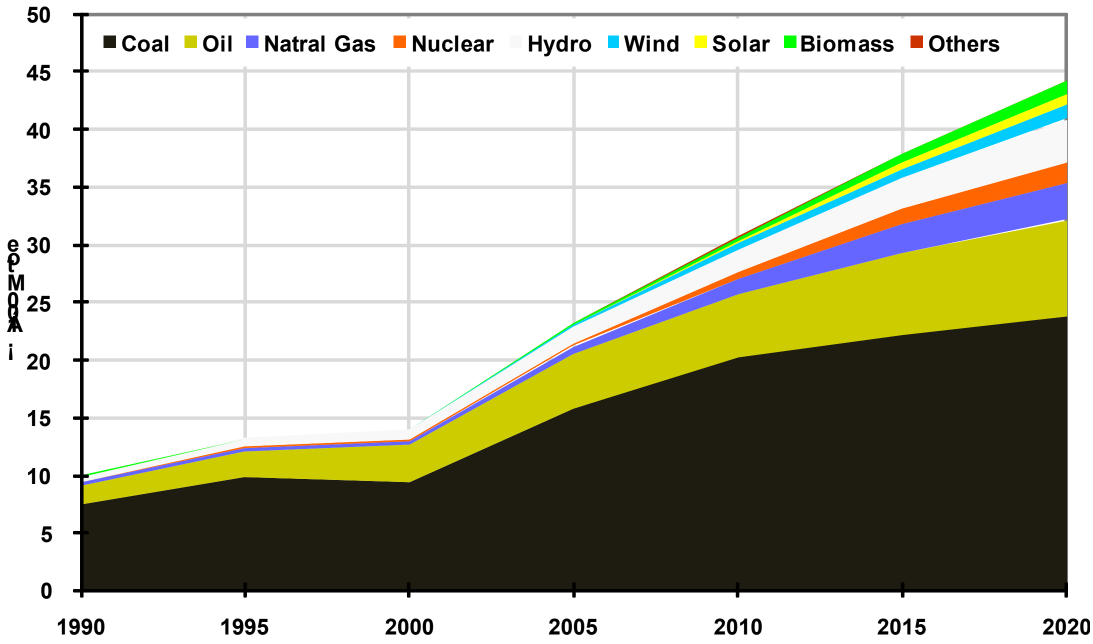
Source: LCIS Task Force analysis

Figure 3-5: Terminal energy demand under CI45 scenario



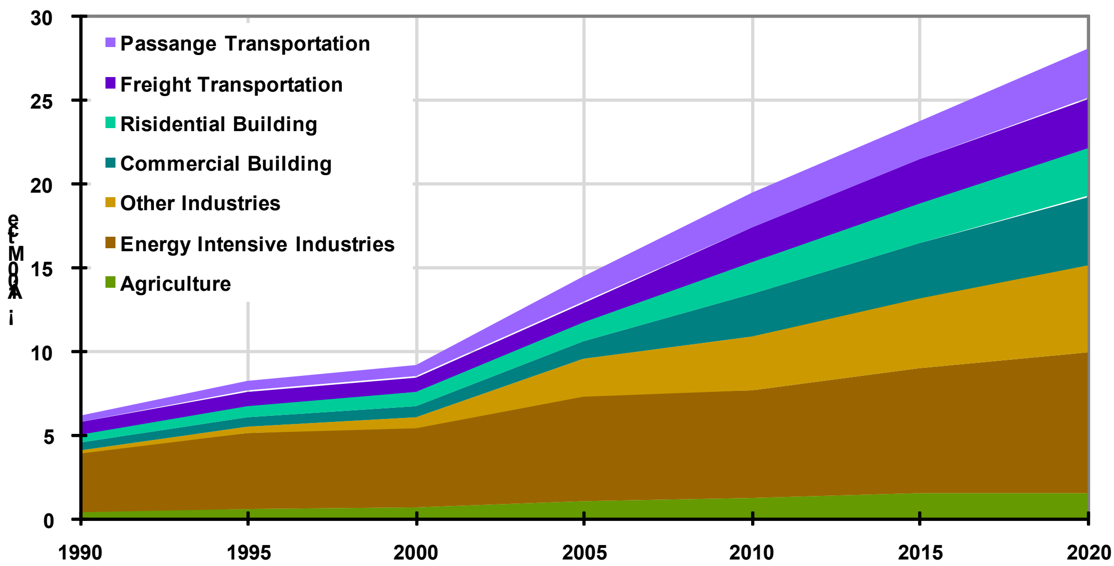
Source: LCIS Task Force analysis

Figure 3-6: Primary energy consumption under CI50 scenario



Source: LCIS Task Force analysis

Figure 3-7: Terminal energy demand under CI50 scenario

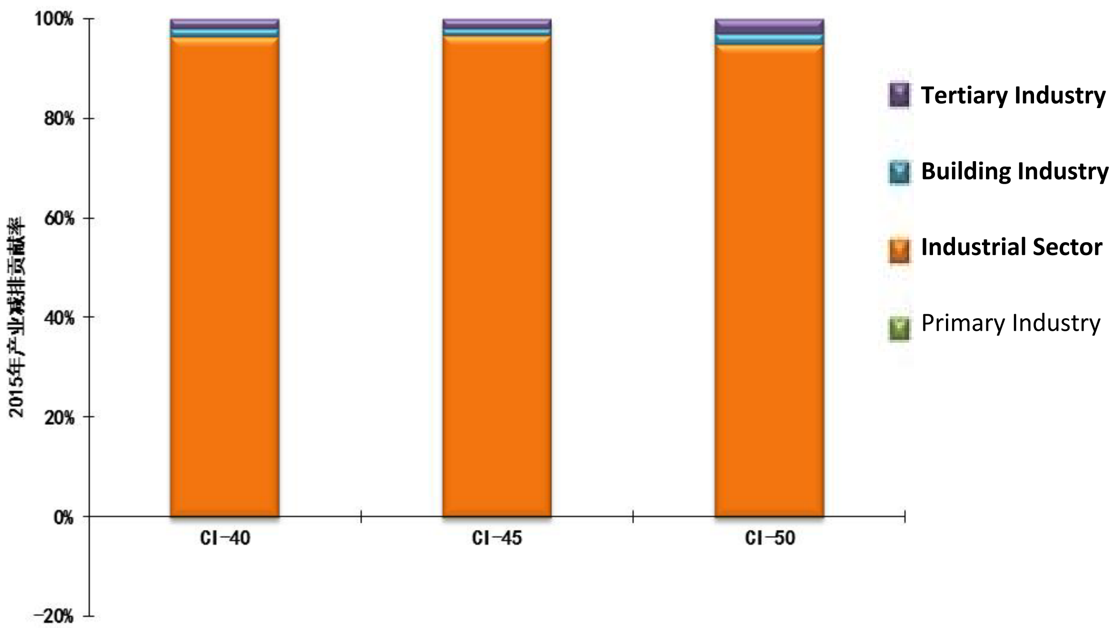


Source: LCIS Task Force analysis

In terms of internal structure of energy consumption, the proportion of terminal energy consumption of manufacturing sector will fall year by year, and is about 63%; the proportion of terminal energy consumption of transportation industry (including aviation, water transport, railway, highway and pipeline transport) will rise year by year, and is about 17%; the proportion of terminal energy consumption of residents' energy use will rise year by year, and is about 13%; the proportion of energy consumption of service industry will rise year by year, and is about 5%. The energy consumption demand of manufacturing industry continues to remain high, which is directly related to the high proportion of energy intensive industries such as steel and cement. In addition, China's industrial structure is hard to be quickly adjusted in short term, which leads to the growing energy demand of manufacturing industry. Although the energy saving effect brought by technical advance can partly offset the energy demand increase brought by increasing service volume of heavy industries, but its effect is limited. Transportation sector will be the main force of China's future energy consumption increase. With the improvement of residents' income level, their demand for travel quality and quantity will also improve constantly. As result, the energy consumption of this sector will increase to be the second largest energy consumption sector only after industrial sector. With the improvement of living standard and residential level, the energy consumption demand of Chinese residents will also grow rapidly, especially the rapid growth of energy demand brought by urban residents. The main reason is that China's urbanization process accelerates and the share of urban residents in total population rises constantly while the energy demand growth of rural residents is mainly from the rapid improvement of the living standard and the constant reduction of urban and rural energy demand gap. With optimization of China's economic structure and adjustment of industrial structure, service industry will play a bigger and bigger role in national economy system in the future and as a result, terminal energy consumption will rise significantly.

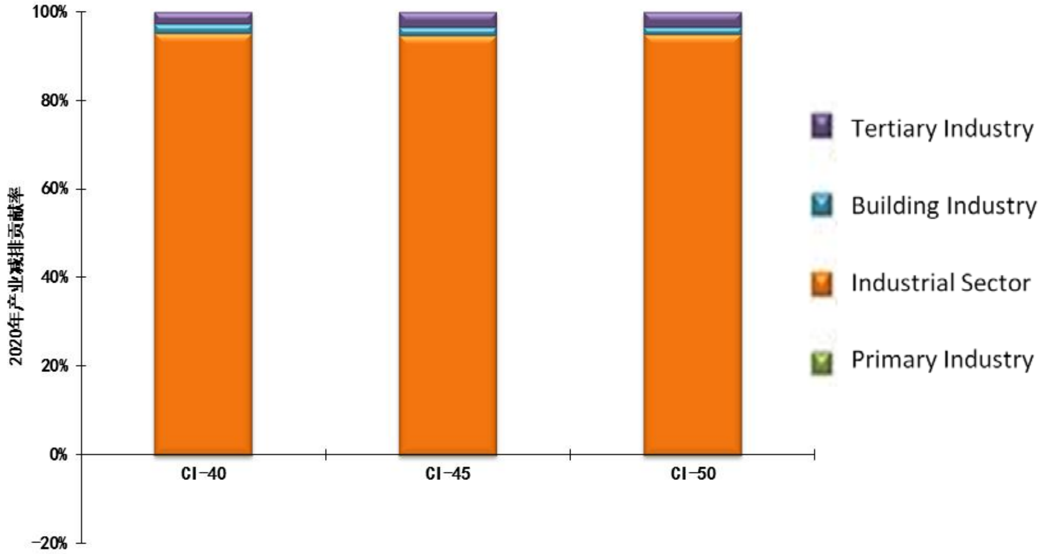
With the economic development and income increase in the next ten years, the energy consumption and emission of living consumption will continue to increase correspondently in the future. So the main contribution to emission reduction will be from the industrial production. According to the scenario analysis (refer to the appendix for details), contribution rates of industrial sector to overall emission reduction will be about 94.5%, 96.7% and 95.1% in 2015, respectively, and about 95.3%, 94.8% and 95.2% in 2020, respectively. Under different carbon intensity policy targets, contribution rates of industrial emission reduction are shown in Figure 3-8 and Figure 3-9.

Figure 3-8: Contribution by industries to emission reduction in 2015



Source: LCIS Task Force analysis

Figure 3-9: Contribution by industries to emission reduction in 2020

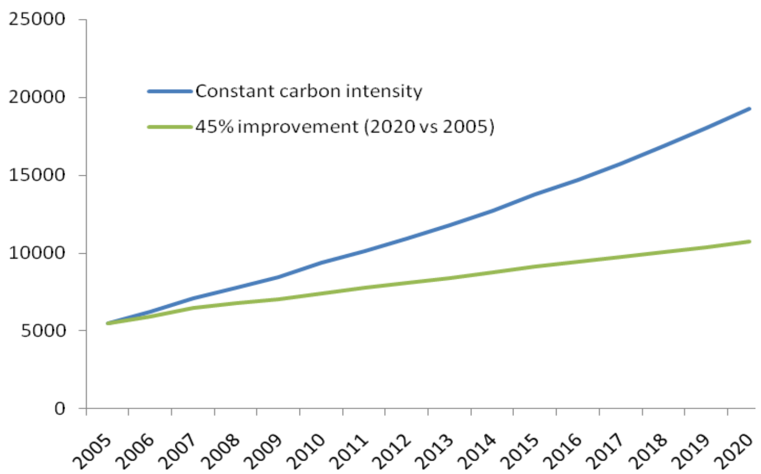


Source: LCIS Task Force analysis

3.2 Key dimensions: efficiency, restructuring and the circular economy

In 2005, the emission volume of carbon dioxide in China was 5,513 Mt while the gross national product was 18.49374 trillion RMB meaning the carbon emission was 2.98 ton/10 thousand RMB per unit of GDP. It is estimated that the GDP of China will be 64.68823 trillion RMB (the price of commodities did not change in 2005) in the year 2020. The emission of carbon dioxide will be 19,285 Mt if the emission of carbon dioxide per unit of GDP did not change. The total emission of carbon can be reduced to 10,728Mt by the year 2020 if the goal of reducing 45% of the emission of carbon dioxide per unit of GDP was realized. The number can be reduced by 8,557 Mt. The contribution of industries to the reduction of carbon intensity was 94.8% which means 8,112 Mt in quantity according to the analysis mentioned above. See Figure 3-10.

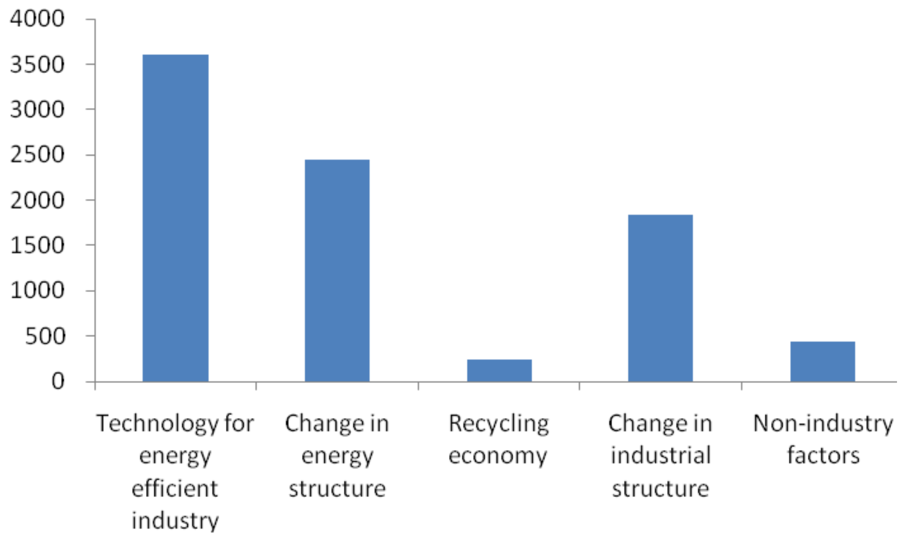
Figure 3-10: Emissions avoided due to 45% carbon intensity improvement in 2020



Source: LCIS Task Force analysis

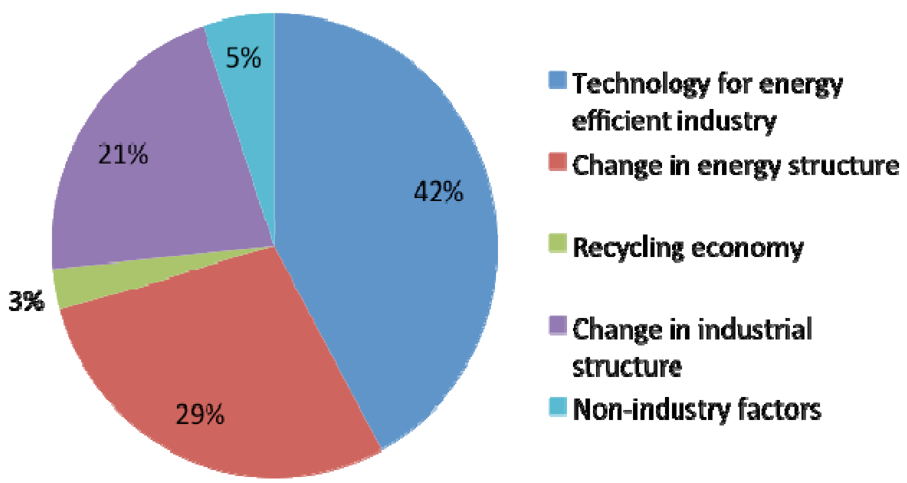
High energy-consuming industrial technology contributed 3,600 Mt to energy saving (see Figure 3-11 and Figure 3-12). The contribution of the optimization of energy structure was 2,440 Mt while the contribution of developing recycling economy was 240 Mt. Therefore, the contribution of adjusting industrial structure should be 1,832 Mt. Except industry, the contribution of other industries was 445 Mt. The proportions were 42%, 29%, 3%, 21% and 5%, respectively.

Figure 3-11: Key areas of emissions reduction potential



Source: LCIS Task Force analysis

Figure 3-12: Key areas of emissions reduction potential (by %)



Source: LCIS Task Force analysis

3.2.1 Increase in energy efficiency of high energy-consuming industries

China's high-energy-consuming industrial sectors, including fields of electric power, steel, non-ferrous metals, petroleum & petrochemical, building materials, papermaking and textiles, are the largest energy intensive industries with most greenhouse gas emission in the country. In the past 10 years, driven by market demand, China's energy intensive industries have gone through a rapid expansion, with energy intensive products seeing an average annual growth of 10%; however, the energy consumed by these industries and the greenhouse gas emitted by these industries also greatly increased correspondently. In 2010, the energy consumption of China's energy intensive industrial sectors accounts for about 56% of the total primary energy consumption. In the next decade, as Chinese economy and society will continuously develop with gradual Industrialization and urbanization, it's estimated that China's energy intensive industrial sectors will still expand in varying degrees, resulting in continuing increase of energy consumption and greenhouse gas emission from these sectors. Therefore, accelerating the transition these sectors from h energy intensive pattern to low carbon pattern will play a crucial part in helping China form the low-carbon industries.

The emission reduction of carbon dioxide will be significant if the industrial added value of high energy intensive industries can be increased. As to reduce energy consumption per added value unit, energy intensive industrial sectors can take methods below: reducing the proportion of energy intensity sub-sectors; increasing the proportion of sectors with high added value; accelerating the improvement of energy conservation technologies in industrial sectors; enhancing companies' energy management level. As to accelerate the improvement of energy conservation technologies, energy intensive industrial sectors can take methods including: setting up and implementing strict regulations on access system of energy intensive industry and energy conservation assessment system for fixed assets investment projects, which can strictly control the energy efficiency of newly-emerging h energy intensive industries; implementing general energy conservation technology transformation in existing energy intensive industries; eliminating backward production capacity of energy intensive industrial sectors in large scale. In addition, mergers and acquisitions between energy intensive companies will greatly increase industrial concentration and enhance energy efficiency. It's estimated that by 2020, the added value of energy intensive industrial sectors will take less than 25% of GDP, with their energy consumption per added value dropping by 40% comparing to 2005, making potential contribution of 1.5-1.6 billion tce of energy to energy conservation and 3.6-3.8 billion t-CO2 to carbon dioxide emissions reduction (detailed analysis is made as follows) .

3.2.2 Adjustment of the energy supply structure

Compared with world's primary energy supply structure, China's primary energy supply structure is high-carbon type. In fact, in China's primary energy supply structure, coal has taken 70% of the total for a long time while non-fossil energy sources only took a small part. This kind of energy supply structure which excessively relies on coal is the basic reason causing the high carbon dioxide emission per GDP in China. Adjustment of the primary energy supply structure is the main method for China to lower its carbon dioxide emission. Realizing the root of this problem, Chinese government has taken the establishment of a safe, stable, economic, clean and low carbon energy system as a long-term strategic task, and has made a clear long-term target that by 2020; the non-fossil energy sources will take 15% of the total energy supply.

In China's 12th Five-year plan, a restrictive target have been made for the first time which requires the proportion of non-fossil energy sources in primary energy supply to increase from current number 8.3% to 11.4% in 2015. This target with legally binding is an obvious signal that Chinese government is determined to accelerate the adjustment of the energy supply structure. The 12th Five-year plan also makes strategic plans on accelerating the adjustment of energy structure supply, including: co-production and co-R&D between industries of synthetic natural gas, coal-produced liquid fuel and coal-base, and make steady progress in Industrialization development; enhancing the exploration and development of oil and natural gas to stabilize domestic oil output, stabilizing domestic oil output, making rapid development in natural gas production and promoting the exploration and utilization of unconventional oil and gas resources such as coal-bed gas and shale gas; using clean coal-fired generators with high capacity and efficiency, as well as using thermoelectric cogeneration generators , building large coal-fuel power plant and power plant which can comprehensively utilize coal refuse in large and medium-sized cities and industrial parks. On the premise of protecting environments and making immigrants settled down, the construction of hydropower plants should be actively promoted, especially the construction of large hydropower plants in southwest area of China. Utilizing the water resources in medium and small-sized rivers according to the local conditions and scientifically planning the construction of pumped storage plant. It's also planned to effectively and safely develop nuclear power station, promote the internet-linked construction, effectively develop wind power station, solar energy, biomass, geothermal energy and other new energies, put distributed energy system into wider use, implement energy conservation strategies with priority, and conduct consumption control, two-way regulation of supply and demand, and differentiated management in coal resources.

Box 3-1: the key energy projects in the 12th Five-year plan

1) The exploration and transformation of coal

Accelerating the construction of coal bases in Northern Shaanxi, Huanglong, Shendong, Mengdong and Ningdong; making steady development of coal bases in northern, middle and eastern part of Shanxi, Yunnan and Guizhou; starting to establish coal bases in Xinjiang and set up several large-sized coal-fuel power plants based on those coal bases.

2) Stabilize the oil output and increase the gas output

Promoting the formation of five large-scale oil and gas production zones in Tarim and Junggar Basin, Songliao Basin, Ordos Basin, Bohai bay Basin and Sichuan Basin. Speeding up the exploration of oil and gas resources in offshore areas and deep-sea areas. Developing the extraction and utilization of coal bed methane in coal mining areas and properly increase the oil refining capacity.

3) Nuclear power

Accelerating the development of nuclear power in coastal provinces, keeping steady development of nuclear power in middle areas, and setting up nuclear power station with capacity of 40 million kW.

4) Renewable energy

Building large hydropower stations in Jinsha river, Yalong river, Dadu river and other main rivers with total capacity of 1.2 billion kW. Setting up six large wind power stations in mainland and two stations in coastal area and on the sea, whose newly-installed generators have capacity of more than 70 million kW. Building solar power stations with capacity of 5 million kW in key areas such as Tibet, Inner Mongolia, Gansu, Ningxia, Qinghai, Xinjiang and Yunnan.

5) Network of oil and gas pipe

Constructing the pipes in the second phase of Sino-Kazakhstan oil pipeline projects, the pipes in Chinese areas involved in Sino-Myanmar Oil and Gas Pipeline, pipes in the second phase of Central Asian natural gas pipeline, as well as pipes in the third and fourth project of West to East Gas Pipeline Project. The total length of the pipelines under the construction is 150 thousand km. Accelerating the construction of gas storages.

6) Power grid

Accelerating the construction of large coal-fuel power station, hydropower station and wind power station which can provide electricity to other regions, building up several across-regional power transmission channels with advanced UHV technology. The length of the constructed electrical power transmission channels with capacity of 330 kV and above reached 200 thousand km. Conducing pilot projects of building intelligent electric grid and intelligent substation. Widening the application of intelligent electric meter and making charging facilities for electric cars.

Source: The 12th five-year plan on national economic and social development

In order to reach the restrictive indicators with non-fossil energy consumption taking 11.4%of the total consumption, Chinese central government and local governments have implemented a package of incentive and restrictive policies on fields of industry, investment, price, financing land, tax and environmental protection. During 12th Five-year plan period, promoted by Chinese government, related administrative departments and industrial enterprises, China’s energy supply structure adjustment will be accelerated. By 2015, it’s possible for China to achieve the interim indicator of 11.4%. By then, the proportion of coal energy in primary energy consumption will drop 7 percentage points compared to 2010, and the proportions of natural gas, hydropower, nuclear power and new energies (wind power, solar power and biomass) will respectively increase by 4%. 1.3%. 1.8%.

In the process of adjustment of primary energy supply structure, power sectors, which are conducting energy transition, are expected to be the pioneer and leader. It’s widely known that power sectors are the largest contributors in reducing carbon dioxide emission. The basic reason for this situation is because Chinese power supply structure is high-carbon pattern. In 2010, the installed capacity of generators reached 962 million kW, 73% of which were fossil-fuel generators (99% of them are coal-fueled); The total power capacity in China reached 4.2 trillion kWh, 80% of which was from fossil-fuel generators. Therefore, accelerating the adjustment of power supply structure and transition to low-carbon is not only the internal needs to keep sustainable development, but also the urgent desire and restrictive requirements that Chinese government put forward to those sectors.

In the 11th Five-year period, in order to meet the increasing demand of electrical power in China’s rapid economic development, Chinese power sectors have gone through a series of unprecedented high-speed expansion. In 2010, the net installed-capacity of the country's generators increased 440 million kW more than in 2005, which provided a valuable opportunity and space for power sectors to adjust the power supply structure. Driven and stimulated by China’s policies of energy conservation, greenhouse gas emission reduction and renewable energies development , Chinese power sectors have taken several important movements to adjust power supply structure and accelerate transition to low carbon pattern, which including: Large-scale elimination of small fossil-fuel generator with low efficiency and high pollution; establishment of clean and efficient coal-fired generators with large capacities; establishment of wind power generators in scale; development of hydropower station and nuclear power station. During this period, , Chinese power supply structure saw a significant progress, eliminating 7200 small fossil-fuel generators, and the growth rate of installed-capacity of fossil-fuel generators declining every year, while the capacity of wind power generator enjoying an annual increase of 96%. Besides, the proportion of hydropower, nuclear power, wind power and other non-fossil –energy- powered generators has increased from 24.4% in 2005 to 26.5% in 2010.

In the next decade, on the purpose to reduce China's carbon dioxide emission intensity and other restrictive targets on energy conservation and emission reduction, the power sectors will accelerate the low carbon development, focusing on the adjustment of power supply structure. Five large power generator companies in China all make their strategic plans on future development, in which the adjustment of power supply structure and transition to low carbon are the main contents. Besides, China's two grid companies also made their own green development strategies, and one of the most important parts is to accelerate the construction of advanced cross-region electricity transmission channels, which can set up a transmission platform to support the structural adjustment. Considering Chinese economic and social development will still have a strong demand for electrical power in future, and the old generators will be eliminated, it's estimated that in the next decade, there will be another rapid expansion in Chinese power sectors, and by 2020, the total installed-capacity of generators in the country will reach 1.7 billion kW, and the installed-capacity of the new generators will reach 0.8 billion Kw, which will provide a tremendous space for the power sectors to adjust power supply structure.

According to the development plan by Chinese power sectors, the basic idea of future power development is: to give priority to hydropower development; to optimize coal power; to actively develop nuclear power; to promote using low carbon energy in power supply; to appropriately develop the natural gas in concentrated power supply to build distributed power station suitable for local condition. Based on these ideas, there are two trends in power supply structure transiting to low carbon: developing more hydropower and shutting down more coal-fired stations; accelerating the development of non-hydropower station. The installed-capacity of the regular hydropower generator units will get to 284 million kW by 2015, and 330 million by 2020; the installed-capacity of pumped storage power station will reach 41 million kW by 2015 and 60 million by 2020. In the fields of coal station, the proportion of coal-field power will decreased by 4~5 percentage points every five year since this year; in the 12th Five year plan, the areas around Bohai, Yangtze River Delta, Pearl River Delta and northern eastern China will strictly control the number of coal power stations, and the development of coal station will move to middle western areas of China, with large coal stations in Shanxi, Northern Shaanxi, Ningdong, Zhungeer and Ordos being the main supply of coal-fuel power. The natural gas power will aim at lessening the pressure on power supply caused by seasonal energies such as nuclear power, wind power and hydropower, and its installed-capacity will hit 60 million kW by 2020. By 2015 and 2020, the installed-capacity of nuclear- powered generators will increase to 42 million kW and 90 million kW; the installed-capacity of wind-powered generators will reach 100 million kW and 180 million kW; the installed-capacity of solar power generators will reach 200 million kW and 20 million kW. The areas not covered by grid extension will take advantages of local resources, which means building small hydropower stations in areas with plenty hydropower resources and developing small-sized wind power stations , solar power stations and geothermal power stations according to the regional conditions of wind, solar and geothermal resources.

The potential contribution from power sectors' supply structural adjustment to China's transition to low carbon will coming in three aspects:The first one is developing non-fossil energy resources in substitution for coal energy. The second one is developing clean, efficient, high-capacity generators units in substitution for the small ones with low efficiency but high emission and consumption. The third is properly developing natural gas power in substitution for coal-fuel power. The research results are listed as below:

- If non-fossil energy will take 15% of the primary energy supply by 2020, at that time ,the total installed-capacity of non-fossil energy generators all over the country will achieve net increase of 500 million kW than 2005 , whose proportion in China's generators installed-capacity will increase to 36.5% from 24.4% in 2005; at the same time, newly-increasing non-fossil energy will be used in power supply and replace coal-fuel power, which will reduce 600 million tce of coal consumption and16t-CO2 of carbon dioxide emission amount .
- By 2020, the proportion of the installed-capacity of coal fuel generators will decrease from 73.6% in 2005 to 60%, and most of them will be clean, efficient generators with large capacity whose efficiency will reach the world's high level. Because the new advanced coal-fuel generators will replace the old and inefficient ones, 260 million tce of energy can be saved, and 7t-CO2 of carbon dioxide emission can be reduced.
- The development of natural gas-fuel generators and its substitution for coal-fuel generators will achieve energy conservation and emission reduction in two ways: one is through on the high efficiency of natural gas powered generators to bring about great energy conservation; the other one is through the substitution for coal. By 2020, it's estimated that the installed-capacity of natural gas powered generators will hit 60 million kW, the potential contribution to energy conservation will get 32 million tce compared to 2005, and the contribution to carbon dioxide emission reduction will get 140 million t-CO2.

3.2.3 Development of circular economy

Developing circular economy is another important way for China's energy intensive industrial sectors to transits towards low-carbon pattern. Chinese government has taken circular economy development as a main strategy for national economy and social development, and also enacted the Circular Economy Promotion Law. During the 11th Five-year plan period, China's energy intensive industrial sectors made active exploration of circular economy development, and got preliminary achievements. In the 12th Five-year plan, circular economy development in industrial sectors is estimated to enter into acceleration stage, and play a more and more important part in the transition of China's high energy-consuming industries to low-carbon.

Good foundation and various advantages are already provided for most energy intensive industrial sectors to develop circular economy. First of all, the pilot projects about circular economy have been implemented in the 11th Five-year plan period, which provide practical methods and patterns as reference for energy intensive industrial sectors to develop circular economy in large scale. Industries of steel, non-ferrous metal, electoral power, chemical industry, building material and paper making business have conducted the pilot projects of circular economy in some related enterprises, which provide effective pattern for circular economy development, and industrial cooperation pattern to cooperate with related industries in recourses recycling. Systematic assessment mechanism for circular economy and some typical enterprises as good example of circular economy development have been established. These practical measures and development patterns from typical enterprises can provide useful examples and references for other energy intensive enterprises to develop circular economy.

Secondly, there are sufficient material basis for China's energy intensive industrial sectors to develop circular economy in large scale. Since the 11th Five-year plan was made, Chinese economy developed very quickly, and people's living standards also saw a great improvement, which led to an increasing demand of energy intensive products and quick growth of these products. At present, China is a great power in producing iron and steel, cement, plate glass, ten kinds of nonferrous metals, caustic soda, soda ash, paper and cardboard. At the same time, since the accumulation of waste steel, metals and paper in society has reached a significant amount, the output of waste resources is gradually becoming very productive. Taking steel industry for example, by the end of 2010, China's crude steel accumulation was more than 5.6 billion tons, and social waste steel accumulation was nearly 18 billion tons, along with annual waste steel output of 54 million tons. Besides, China has initially established a waste-resources-recycling system. All of these conditions signify the material basis required in developing circular economy in energy intensive industries like steel, non-ferrous metals and papermaking have been ready.

Box 3-2: Key circular economy projects in 12th Five-year plan

1) Comprehensive utilization of resources

Supporting the utilization of large bulk solid wastes such as associated and symbiosis mineral resources, fly ash, coal refuse, industrial by-product gypsum, smelting wastes, chemical waste residue, tailings, construction wastes, as well as straws and waste wood. Setting up several resource utilization bases.

2) Recycling system of waste product

Setting up 80 demonstration cities with waste product recycling systems which are rationally distributed and operated under regulated management, with multiple recycling methods and high recycling efficiency of key products.

3) Demonstration bases of "mineral industry in city"

Establishing 50 demonstration bases of "mineral industry in city" with advanced technology and regulated management, complying with environmental standards, and having radial impact and scale effect, in order to recycle the waste metals, waste electrical and electronic products, waste paper and plastics in large scale and with high value.

4) Industrialization of remanufacturing

Building several national remanufacturing zones, and nurturing several remanufacturer business covering fields of automotive parts , construction machines, mining machines, machine tools and office supplies, so as to achieve the sound development of remanufacturing industry in scale and Industrialization . Improving the standard system of remanufactured products.

5) Reclamation of kitchenware waste

Building several kitchenware waste reclamation facilities in 100 cities (districts) with advanced technology and good economic returns, to get better utilization and harmless disposal with kitchenware waste.

6) Recycling transformation in industrial park

Making recycling transformation in main industrial parks or industry cluster areas.

7) Promotion of resources recycling technology

Making certain demonstration projects and service platforms which are consistent with circular economy, exclusively used for several important technologies, helping for the production and application of whole set of machines.

Source: The 12th five-year plan on national economic and social development

In addition, it's important to realize that China's central government and local governments have already put forward a series of important measures aiming to promote the circular economy development, which includes plan and guidance, promotion construction projects, economic incentives and regulatory restrictions.

The 12th Five-year plan makes very clear that China will make great effort to develop circular economy. By 2015 the comprehensive utilization of industrial solid waste rate will reach to 72% and the yield rate of resources will increase by 15%; more supportive fiscal and financial policies will be made; laws, regulations and standards will be perfected. China will introduce an extended responsibility system, as well as the name lists of technologies and products involved in circular economy, set up sign system of remanufactured products and statistical and evaluation system for circular economy; the technologies which can be used in energy conservation at initial stage, recycling ,remanufacturing, making zero emission and cooperation among various industries will be developed and used; the typical pattern of circular economy should be widely promoted; actives which can promote the national demonstration bases of circular economy will be carried out, and the circular economy "Demonstration campaign " will be organized. The plan also mentions carrying out six major circular economy projects.

In 2010, National Development and Reform Commission, together with People's Bank of China and other administrative departments made 'Opinions on Investment and Financing Policies to Support Circular Economy Development', in which they put forward establishing an investment and financing policy system to support circular economy development, including measures of : increasing financial support for investment in circular economy; making researches on and improving industrial policies to enhance circular economy development ; conducting researches and formulating policies of prices and charges; improving and upgrading the overall financial services to support circular economy development; exploring more direct financing channels, such as encouraging equity investment fund and venture capital investment to provide financial support through various debt financing products, supporting enterprises which use recycling resources to get listed on stock market, and encouraging foreign loans to support projects related with circular economy. At present, National Development and Reform Commission are making <The circular economy development plan in 12th Five-year plan period>. And at local government level, many governments of provinces and cities also make local plans about circular economy development, or plans focusing on special industrial sectors. (For example: Gansu, Henan, Hebei, Zhejiang, Shenzhen, Dalian, etc) Some local governments even set up special funds for circular economy development (such as Fujian). The implementation of these policies is estimated to provide effective incentive and necessary restriction for China's energy intensive industrial sectors to develop circular economy.

Box 3.3: The overall plan of circular economy in Gansu

After active development of the circular economy ,Gansu province is estimated to see a drop of its resource consumption indicator by 2015 comparing to 2005, with energy consumption per industrial added value unit will decrease by 35%□and energy consumption per ton of nickel down to 3.59tce/t nickel. Meanwhile, the comprehensive utilization indicator in Gansu will see an obvious growth with comprehensive utilization ratio of industrial solid waste rise from 29.43% to 74%, recycling ratio of waste iron steel, non-ferrous metals, paper, and plastic and rubber rise to77.7%. 84.4%. 74.5%. 75.0%. 86.5% respectively. 10 million tce of energy will be saved and more than 20 mt of CO2 will not be emitted.

Source: The overall plan of circular economy in Gansu

Based on principles of taking reducing energy consumption as priority, China's energy intensive industrial sectors focus on improving resources output efficiency as prime target in circular economy development. But as the accumulation of waste resources increases in the future, and the technologies of utilization and recycling keep expanding, the circular economy development in energy intensive industrial sectors will gradually change the principles from taking energy consumption reduction as priority to putting same emphasis on energy consumption reduction, reutilization and reclamation. Through circular economy development, it will help China's energy intensive industrial sectors increase resource output efficiency, waste recycling efficiency, lower the consumption of energy, water, raw material per unit, and reduce the waste amount and carbon dioxide emission. According to researches, using waste steel in steelmaking can saving 60%[87] of the energy than using iron made of iron ore. It's estimated that, comparing to the primary metal production, one tone of output of recycled copper, recycled aluminum and recycled lead can respectively save 1054kgce. 3443kgce. 659kgce of energy, and also reduce carbon dioxide emission[88].

In the next decade, developing industrial circular economy will significantly support and promote the energy intensive industrial sectors to transits to low-carbon pattern. Take the non-ferrous metal as an example, major secondary non-ferrous metal production in 2010 exceeded seven million tons, accounting for about 23% of non-ferrous metal production, which equals to a consumption reduction of over 10 millions of standard coal or around 30 million tons of carbon dioxide by primary metals. In the next ten years, non-ferrous metal industry will vigorously develop secondary metals imports processing parks and secondary metal utilization industries, strengthen the comprehensive utilization of resources, innovate models, create a new system of recycling non-ferrous metal industry and improve the utilization level of recycled metal. It is estimated that by 2015, the main secondary metal production would add up to 11.1 million, of which 380 million tons are recycled copper, 580 million tons are recycled aluminum and 150 million tons are secondary lead. Secondary refined copper, secondary aluminum and secondary lead will account for over 58%, 29% and 30% of the production of refined copper, electrolytic aluminum and refined lead. By 2020, secondary metal recycling capacity will reach 12.4 million tons. The emission of carbon dioxide can be reduced by 240 Mt through the development of recycling economy if the production volume of steel scrap was 80 to 100 million ton by the year 2020.

3.2.4 Adjustment of industrial structure

The adjustment of industrial structure plays a critical role in realizing the target of emission reduction of carbon. The proportion of industry in GDP should be decreased from 41.8% in the year 2005 if the emission reduction of carbon intensity should be decreased by 40%, 45% and 50% according to the scenario analysis. The more of carbon intensity decreases the more of the proportion of industry decreases. By the year 2015, the proportion of industrial added value will be about 38.7%, 38.2% and 37.7% while the number will be 36.7%, 36.5% and 35.2% by the year 2020, respectively. Currently, the industrial added value per unit of carbon emission is 2 to 3 times of that in the service industry and the proportion of industry can reduce the carbon emission significantly.

Figure 3-13: Change in industrial structure by the year 2015

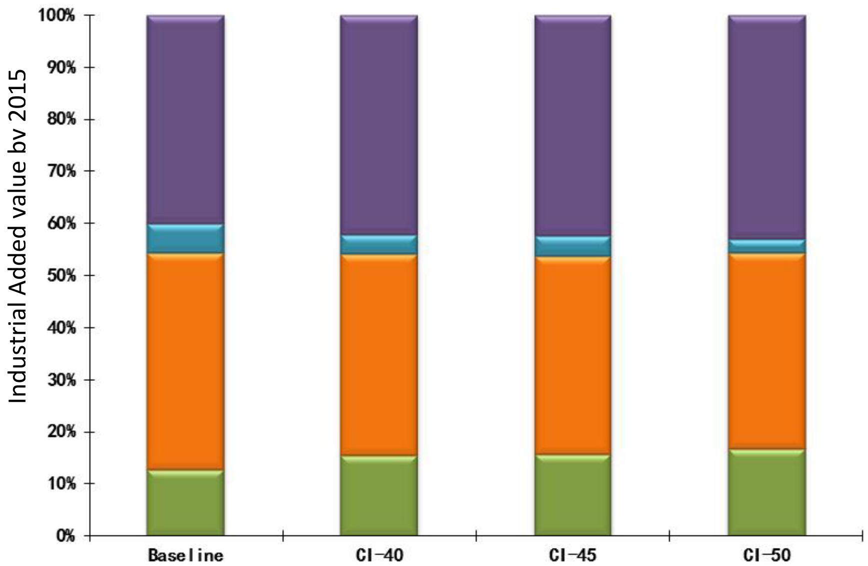
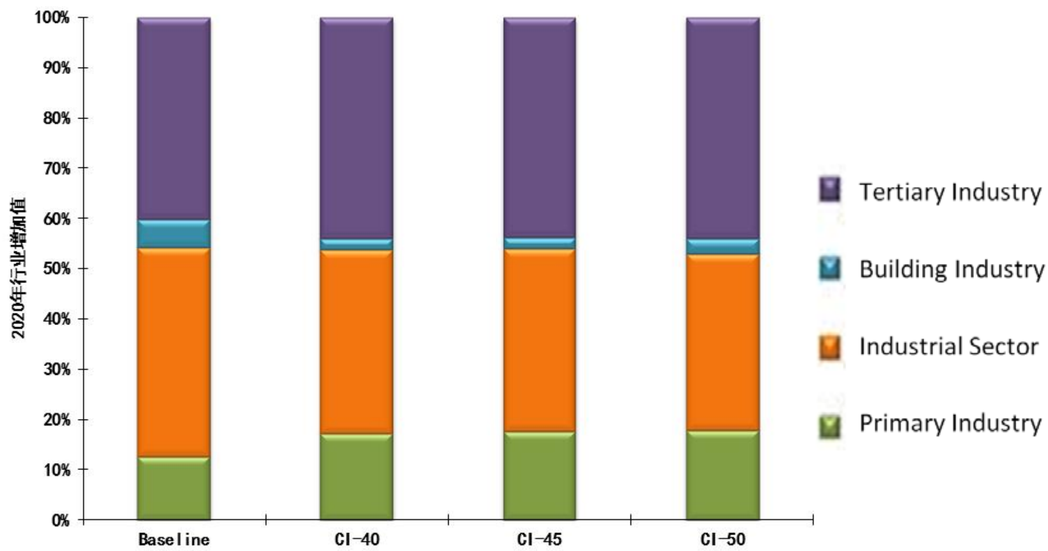


Figure 3-14: Change in industrial structure by the year 2020



Source: LCIS Task Force analysis

The adjustment of internal structure also plays a significant role. The change of internal structure in industry can be seen in Fig. 5-11 and Fig. 5-12 under different policy target of carbon intensity. The proportion of the top 10 high energy-consuming and high emission industries reduced from the current about 50% to about 38.1%, 36.6% and 35.3% by the year 2015 and about 33.5%, 31.8% and 26.8% by the year 2020, respectively. The number decreased significantly. The larger the target of carbon intensity is the larger of the reduction of total industrial output value will be. In China, The significant decrease of the proportion of added value of high energy-consuming industries in GDP will bring considerable reduction in emission of carbon dioxide. The calculation result showed that the energy saving potential will be ranged from about 80 to 85 million tce if the proportion of high energy-consuming industrial added value decreases by one percentage point compared to the proportion in 2005 by the year 2020.

Figure 3-15: Change of industrial structure in 2015

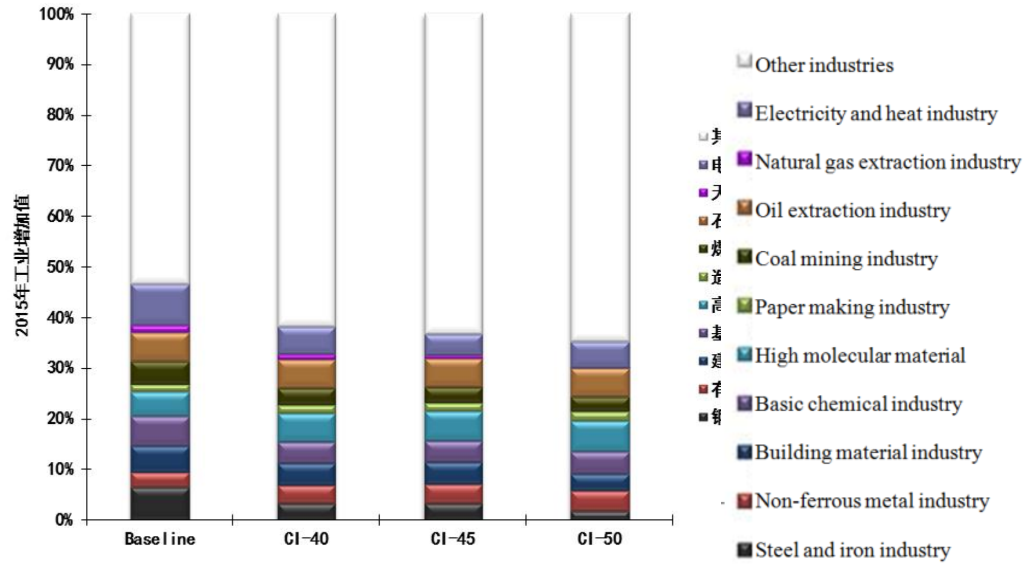
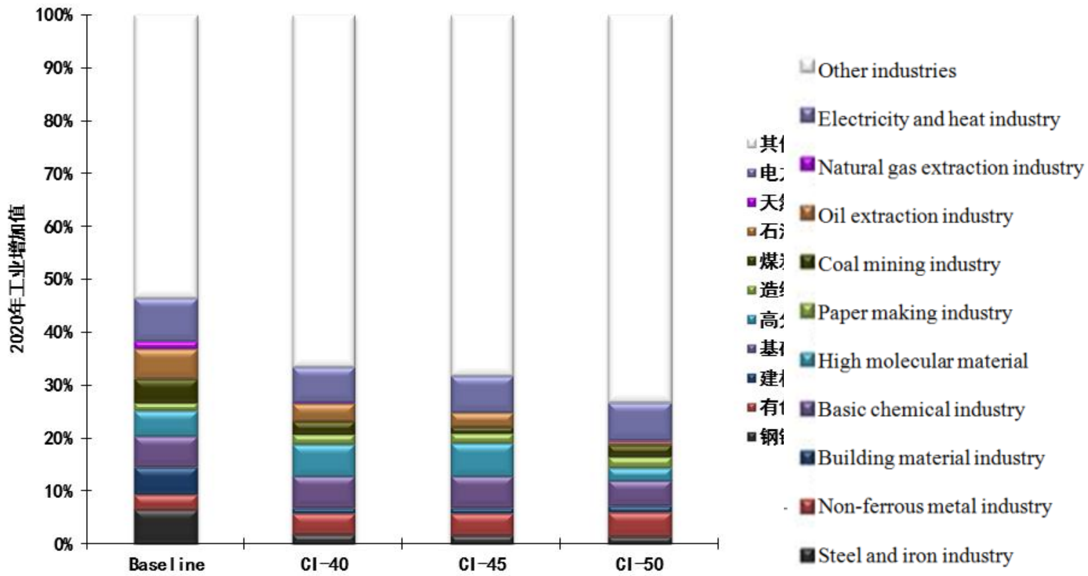


Figure 3-16: Change of industrial structure in 2020



Source: LCIS Task Force analysis

Although China has already become a sizable industrial nation, it is far from a strong industry powerhouse. This is mainly manifested by the fact that the product added value rate remains low and corresponding economic output of unit consumption of energy and greenhouse gas emissions has much room for improvement. In 2007, the added value rate in China's manufacturing sector was 26.45%, far below the average level of 35% of developed countries, especially the level of US, 45.93%. In the future, China will adopt various measures to encourage enterprises to increase R&D investment, enhance the capability of new product R&D, move to the high end of industrial chains, and keep raising product technology content. These will help promoting the international competitiveness of the products, raising product added value, and further increasing the output efficiency of energy input.

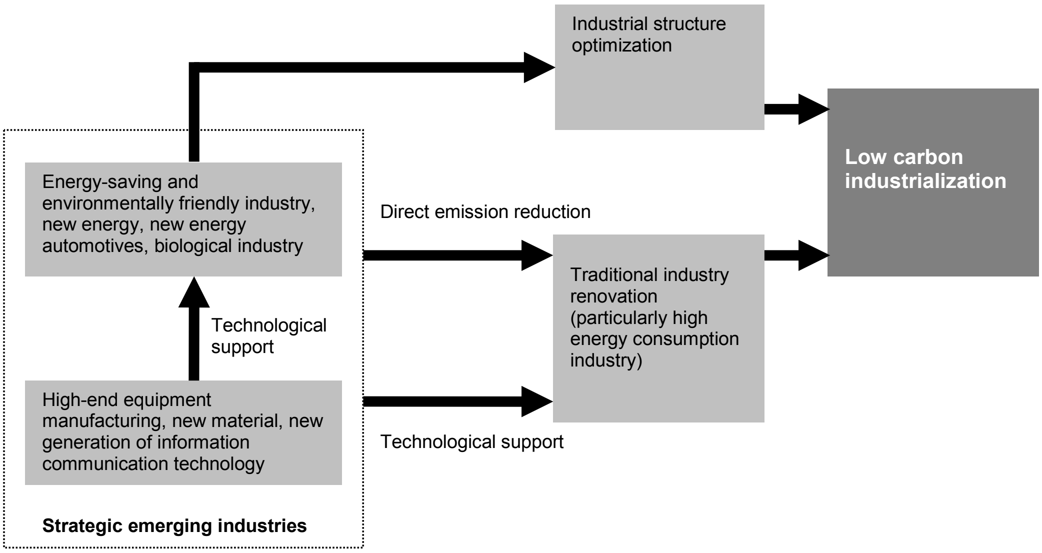
A reduction of 1,832 Mt of carbon dioxide can be realized through adjustment of industrial structure by taking into consideration of the three times of adjustment in industrial structure, the adjustment of internal structure in the secondary industry and the elevation of the rate of industrial added value mentioned above.

3.3 Energy-intensive and emerging strategic industries are the two pillars

As mentioned above, the reformation and upgrading of the high energy-consuming industry played a critical role in the development of the low carbon Industrialization in China. For instance, the emission of carbon dioxide in high energy-consuming industry can be reduced by 3.6 to 3.8 billion ton through the elevation of energy efficiency. Except the high energy-consuming industry, strategic new industries like energy saving and environmental protection, low carbon energy, low carbon energy automobile, biological industry, the new generation of information technology, new materials and high-end equipment manufacturing industry can also play a supporting role in the development of the low carbon Industrialization.

The development of the strategic new industries can make contribution to the low carbon Industrialization in three ways. First, the traditional industries and direct reduction of industrial carbon should be reformed and upgraded. For instance, the enhancement of the energy efficiency in the high energy-consuming industry was realized by the development of the energy saving and environmental protection industry. Moreover, the optimization of the energy structure benefited from the development of the low carbon energy to a large extent. Second, the invention and innovation of new materials, new equipment and new information and communication method can provide support to the reformation and upgrading of traditional industries. Third, the development of strategic new industry will optimize the industrial structure and increase the rate of added value. Thus, the carbon productivity of the industrial departments can be increased.

Figure 3-17 - Processes of low carbon Industrialization



Source: Development Research Center of the State Council, 2011

The emerging strategic sectors can contribute to China's low carbon Industrialization in three distinct ways, as shown in Chapter 1 sets out the trends that will help define the global landscape over the next 10 to 20 years, the critical period for China's low carbon Industrialization. A resurgence of manufacturing and focus on low carbon industries in key markets makes this a vital area for China's future competitiveness. There is considerable international experience in promoting low carbon industries, especially in the past two decades. Strengthening China's innovation capacity and promoting an open an inclusive approach are the key to successful transition.

Chapter 2 provides an overview of China's industrial and energy situation, highlighting the strong foundation for taking a lead on low carbon industry but also the challenges that need to be addressed.

Chapter 3 explains that low carbon Industrialization is central to meeting China's broader objectives on the low carbon economy. The key dimensions are energy efficiency in industrial sectors, industrial restructuring and reorganization and the emergence of new pillar industries. In each area, innovation will become increasingly important over time.

Chapter 4 provides a detailed explanation of the role of seven energy intensive industries in low carbon Industrialization, underpinned by detailed technical analysis.

Chapter 5 assesses the potential of the seven emerging industries, including their role in supporting improvements in heavy industry and more fundamental restructuring of the energy and economic systems.

Chapter 6 presents specific policies and recommendations for China's low carbon Industrialization. First, energy-saving technology and low carbon energy sectors will reduce the energy consumption and emissions of heavy industries. Switching to renewable energy, for example, will reduce emissions from the power-hungry aluminium sector, while 'waste' heat from industrial processes can be utilized through combined heat and power systems, driving up overall efficiency. Deeper improvements often require change at the system level. Electric vehicles, for example, can act as storage for the grid, reducing peak capacity.

Second, advanced materials, high-end manufacturing, biotechnology as well as information and communications are sectors that will provide key technologies to the energy-intensive industries as they upgrade. These range from lighter, stronger materials to data-driven analysis of the whole supply chain. These sectors are also in the front line in the search for low carbon alternatives to energy-intensive products such as cement, steel and fossil fuels – potential breakthroughs with potentially transformative impacts.

Finally, these seven emerging industries will contribute an increasing share of China's GDP, reaching 15% by 2020 according to China's current ambition. Meanwhile, the share of heavy industries in overall GDP will decline. This shift in economic structure will play a key role in reducing the country's energy and carbon intensity beyond 2020, since the emerging pillars tend to require much less energy and resources per unit of economic output than traditional sectors.

3.3.1 The development of strategic emerging industries can renovate and upgrade traditional industry and directly reduce industrial carbon emission

The development of energy-saving and environmental-friendly, low carbon energy, low carbon energy automotives and biological industries can improve the utilization rate of energy, replace fossil energy and traditional materials, reduce pollutant emission and directly reduce industrial carbon emission. For example, according to the following analysis, by reducing energy consumption in industrial processes, developing a circular economy and developing high-efficient, energy and material-saving products, the development of energy-saving and environmental-friendly industry can save 356 million tons of coal equivalent, reduce 818 million tons of CO2 emission by 2015 and save 834 million tons of coal equivalent and reduce 191.2 million tons of CO2 emission by 2010 (contribution from the development of energy-saving and environmental-friendly automotives is excluded). The development of low carbon energy can replace fossil energy. It is estimated that by 2015, 467 million tons of fossil energy can be replaced by low carbon energy which equals to a reduction of 1.15 billion tons of greenhouse gas emission; and by 2020, 720 million tons of fossil energy can be replaced which equals to a reduction of 1.771 billion tons of greenhouse gas emission. The development of low carbon energy automotives will reduce greenhouse gas emission from material flow and personnel flow in the process of Industrialization and the development of biological industries particularly biological manufacturing can replace the traditional materials needed in the process of Industrialization by biological materials and reduce energy and resource consumption and greenhouse gas emission (Table 3-1)

Table 3-1: Impact on Emission Reduction of Development of Strategic Emerging Industries

	Emission Reduction Effect (CO2)		Note
	2015	2020	
Energy Saving and Environmental Protection	818 million tons	1.912 billion tons	Direct Effect
Low carbon energy	1.15 billion tons	1.771 billion tons	Direct Effect

Low carbon energy Automotive		300 million tons	to reduce industrial emission by reducing emission from material flow and personnel flow
Biological Industry	can replace oil and serve as an industrial material		Direct Effect
Information Communication Industry	615 million tons of emission will be reduced by 2020 and the ratio of direct emission reduction to indirection emission reduction is 1:5		the ratio of direct emission reduction to indirection emission reduction is 1:5
New Material	Will have an important impact on resources saving, environmental treatment and material recycling and reutilization		Indirect Effect
High-end Manufacturing Industry			

Note: Due to the crossover and differentiation in comparison benchmark in the above emission reduction effect, the results cannot be directly overlapped or used to compare with the results of the model analysis.

3.3.2 The development of strategic emerging industries can provide support for renovation and upgrading of traditional industries

The new generation of information communication technology, new materials and high-end manufacturing industries will provide new materials, equipment and information communication technology for the renovation and upgrading of traditional industries and the development of energy-saving and environmental-friendly, low carbon energy, low carbon energy automotives and biological industries and thus will provide strategic support for the low-carbon Industrialization process. For example, low carbon energy such as wind power and solar power is characterized with intermittence and large-scale application might have an impact on the safe operation of the power grid. As a result, reliability of the power grid should be improved through development of smart power grid, better connection between the suppliers and providers so as to support the large-scale development of low carbon energy. Another example is that light and strong new structural materials such as high performance composite and high performance light metallic materials (Aluminum, magnesium, titanium and relevant alloys) will have a big advantage in terms of energy saving and resource consumption reduction in aerospace, automotive, transportation, marine and construction industries.

3.3.3 The development of strategic emerging industries will optimize industrial structure, enhance the industrial added value and thus enhance the carbon production rate of industrial departments

Strategic emerging industries can not only renovate and upgrade traditional industries, lower energy and resource consumption and greenhouse gas emission in traditional industries, but also help improve industrial structure, lower down the proportion of high energy consumption and high pollution industries in the overall industries and improve the added value rate of the industries since strategic emerging industries are characterized with low energy and resource consumption and high added-value. As planned, strategic emerging industries will account for 8% and 15% of the GDP by 2015 and 2020 respectively, which will improve the industrial structure significantly and the carbon productivity of industrial departments.

3.4 The pivotal role of innovation

Related technology should be provided as support and basic guarantee not matter it is to increase the energy efficiency of high energy-consuming industry, to develop circular economy, to adjust energy structure or to develop strategic new industry.

During past few years, Chinese energy intensive industrial sectors have made great effort on the development and promotion of low carbon technologies, especially the technologies about industrial energy efficiency. Many important industrial energy efficiency technologies, such as ultra and supercritical fossil-fuel technology, CDQ technology, technology of utilizing differential pressure of BF gas to produce electric power, technology of utilizing cement kiln waste heat to produce electric power, technology of using ammonia for energy conservation, regenerative combustion technology, etc, are developing quickly. In the 11^{th} Five year plan period, China's energy intensive industrial sectors have achieved remarkable results in energy conservation: energy consumption per added value decreased more than 22%; in one thousand energy intensive enterprises , their comprehensive energy consumption indicators in production of alumina, ethylene and caustic soda dropped more than 30%; comprehensive energy consumption per unit in crude oil processing, electrolytic aluminum production and cement production decreased more than 10%; the coal-fired power consumption decreased nearly 10%. All of these led to 1.5 billion tce of energy conservation, and 3.5 billion t of CO2 in carbon dioxide emissions reduction. The basic reason lies in development and promotion of key energy conservation technologies in industrial business, offering the crucial support. In fact, the one thousand energy intensive enterprises have contribute 3.5 billion t-CO2 to carbon dioxide emissions reduction, most of which were achieved through using industrial energy conservation technologies[89].

With regard to China's energy intensive industrial sectors, at present there are at least hundreds of available and mature energy efficiency technologies. However, because of technical risk, financial risk, lack of investment and information, there are several market obstacles in energy conservation in different ways in China ,just the same as in other countries, which had negative result that a large part of those available energy efficiency technologies were not widely used ,with less than 10% ,even only1% utilization rate. On the other hand, as time goes on and technology keeps developing, there will be more and more low carbon energy conservation technologies that could be used in energy intensive industrial sectors. This means, by developing and using industrial energy conservation technologies, these industrial sectors still have great potentiality in energy conservation and carbon dioxide emissions reduction in the future.

For a long time, Chinese government always take energy intensive industrial sectors as main fields in energy conservation. The government also takes the development of low carbon technologies, especially the development and application of industrial energy conservation technologies as the most important and feasible methods to promote the transition of energy intensive sectors to low carbon ones, and will take series of major policies and measures to achieve the goal. It's clearly mentioned in the 12^{th} Five year plan: developing energy-conservation and environmental friendly strategic new industries, establishing the demonstration projects of energy conservation and environment protection; accelerating the development of Industrialization of energy conservation, environment protection and comprehensive unitization of resources; conducting major projects on energy conservation transition, Industrialization of energy conservation technology and contracted energy management. In addition, Chinese government will set up strict industry access system for energy intensive business, and mandatorily eliminate energy intensive businesses with low efficiency and high emission, which will create more market space and favourable conditions for energy intensive industrial sectors to develop and use advanced energy technologies.

Box 3-3: key projects on energy conservation in 12th Five year plan

1) Projects on energy conservation and transition

Continuing the cogeneration, optimization of energy system in motor equipment, utilization of surplus heat and pressure, reformation of boiler (kiln), projects of saving and replacing oil, energy saving in building and traffic, and green lighting.

2) Projects on popularization of energy conservation production for the convenience of the people

Putting more financial subsidies to the energy saving and high efficiency products of electrical appliances, automobiles, motor equipment and lighting.

3) Demonstration project of Industrialization of energy conservation technology

Supporting the demonstration of key crucial energy conservation technologies and products about utilization of surplus heat and pressure, and highly-efficient generators; promoting the large-scale production and application of products with crucial energy conservation technologies.

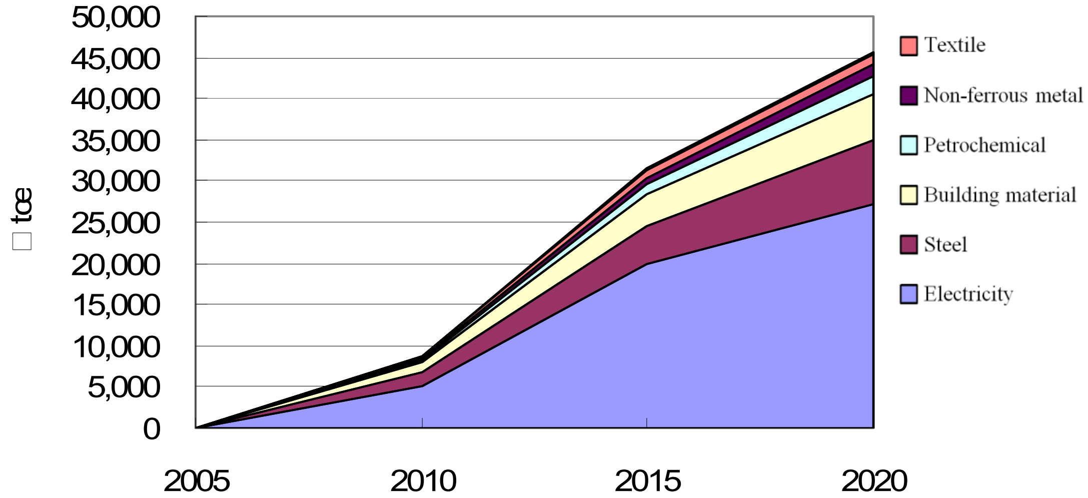
04 Project of contracted energy management

Promoting the energy conservation service companies to use contracted energy management to reach the energy conservation target, and supporting the development and growth of energy conservation service industry.

Source: The 12th five-year plan on national economic and social development

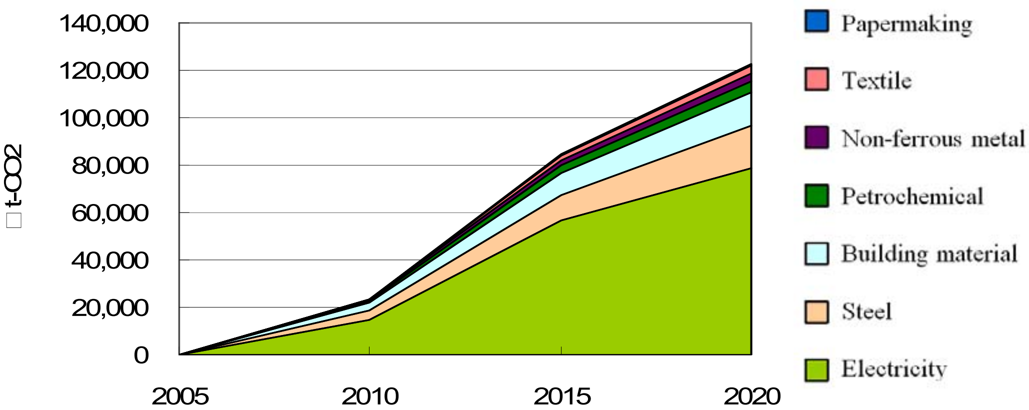
The analysis on energy conservation potentiality of the promotion and application of existing 79 kinds of key industrial energy efficiency technologies shows that: in the next decade, if the energy intensive industrial sectors can widely use these 79 kinds of technologies, then by 2020, there will be 456 million tce of energy conservation accumulation, and 1.22 billion t-CO2 in carbon dioxide emissions reduction. If all the energy efficiency technologies (including existing ones and newly-emerging ones) which can be used in energy intensive sectors be widely and immediately used, then by 2020, there will be 0.65-0.75 billion tce of energy conservation accumulation, and 1.7-1.9 billion t-CO2 in carbon dioxide emissions reduction. Of course, there are many uncertain factors impacting on whether those energy conservation targets could be achieved or not, and one of the most important factors is whether there will be enough investment used in development and promotion of industrial energy conservation technologies in time. The analysis tells us: just the required money in promotion those 79 kinds of existing industrial energy conservation technologies[90] will cost energy intensive industrial sectors nearly one trillion RMB during 2011~2020; if all the energy technologies that can be used in energy intensive industrial sectors get timely promotion and application, then the money needed in energy efficiency investment will hit 1.6-2.0 trillion RMB in the next decade[91].

Figure 3-18: The potentiality of the promotion and application of 79 kinds of crucial industrial energy conservation technologies in energy conservation. (2006-2020)



Source: LCIS Task Force analysis

Figure 3-19: The potential of the promotion and application of 79 kinds of crucial industrial energy conservation technologies in CO2 emission reduction. (2006-2020)



Source: LCIS Task Force analysis

4 THE ROLE OF ENERGY INTENSIVE INDUSTRY

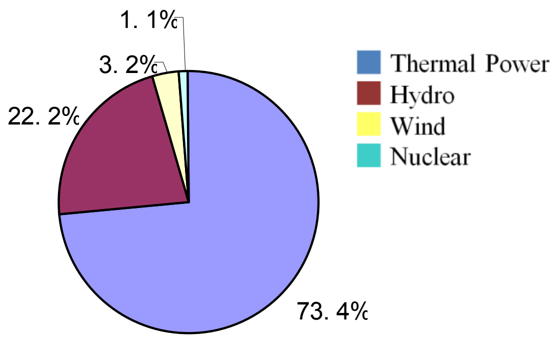
The issue of the low carbon development of high energy-consuming industry will be discussed in this chapter. The current situation, potential in emission reduction, paths of emission reduction and the policies and measures required in high energy-consuming industries including the power sector, steel, building materials, petrochemical industry, non-ferrous metal, textile industry and paper-making industry will be presented.

4.1 Electric Utility Industry

4.1.1 Current situation and trend of development

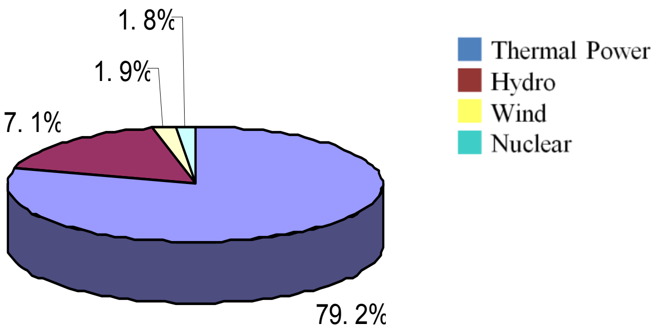
The global financial crisis broke out in 2008 also affected China, especially for those energy intensive industries. However, China's economy still keeps an astonishing growth of 11.2% average annual. Rapid growth of China's economy enormously stimulates power demand and electric utility industry, which as the basis of national economy, has gone through an unprecedented high speed expansion. Until 2010, the national generating installed capacity increased to 96.219 million kW, which has a net increase of 450 million kW over 2005. Among these are 706.63 million kW on fossil-fuel power, 213.4 million kW on hydropower, 31.07 million on wind power and 10.82 million on nuclear power, which respectively share a proportion of 73.4%, 22.2%, 3.2% and 1.1% of national generating installed capacity. With a national power generation of 4206.5 billion kWh, among these are 3330.1 billion kWh on fossil-fuel power, 721 billion kWh on hydropower, 81.5 billion kWh on wind power and 73.9 billion kWh on nuclear power, which respectively share a proportion of 79.2%, 17.1%, 1.9% and 1.8% of national power generation. Thus China has become the world's second power producer.

Figure 4-1: China power supply structure 2010



Source: LCIS Task Force analysis

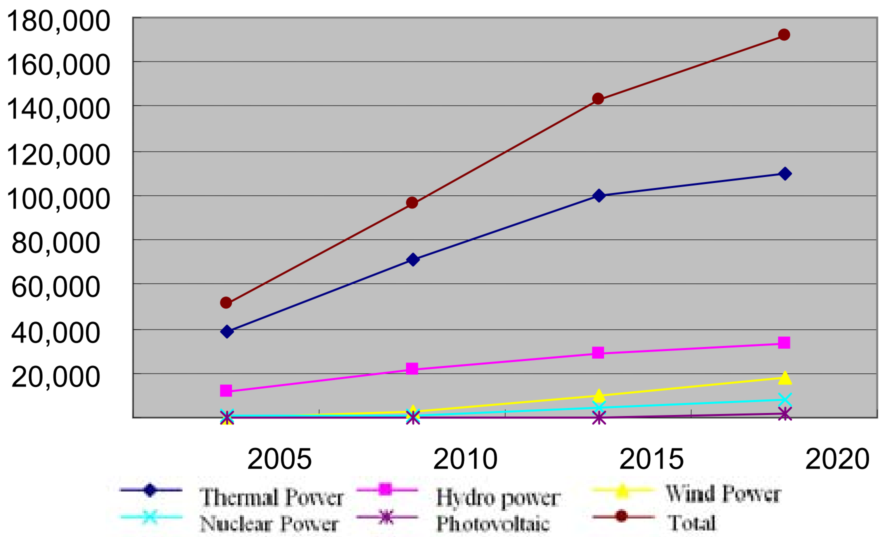
Figure 4-2: China generated energy structure in 2010



Source: LCIS Task Force analysis

China is in a development period for accelerating Industrialization and urbanization, building well-off society in an all-around way for the next ten years. It is also predicted that China's economy will still maintain high growth rate, economic growth and growth in living standard will bring an increasing power demand. Besides, Chinese government takes low carbon energy vehicles as a strategic and emerging industry, as a result, the gradual popularization of future plug-in hybrid vehicles and pure electric vehicles will bring new power demands. On the whole, driving forces for China's future electricity demand are relatively strong with another round of rapid expansion of electric utility industry. It's predicted that the national generating installed capacity will increase to 1.7 billion kW with a national power generation of over 8000 billion kWh. The development of future electric utility will take support realizing a prospect as a basic orientation, which is proposed by Chinese government that non-fossil fuels in primary energy consumption reaching to the proportion of 15%. Thus, there will be a big adjustment in power supply, with a great increase in the installed capacity of hydropower, nuclear power, wind power and solar power. Newly added coal generation will basically be the clean, efficient and big capacity fossil-fuel power unit. Therefore, there will be a significantly decrease in proportion of fossil-fuel power installed capacity in national generating installed capacity. The proportion of high efficient and low effluent natural gas power generation capacity will increase as well.

Figure 4-3: China power growing trend from 2005 to 2020 (10,000kw)



Source: LCIS Task Force analysis

4.1.2 Low carbon evolutionary path and potential contribution of the low carbon fossil-fuel power

(1) Low carbon fossil-fuel power development of the "Eleventh Five-Year Plan"

For a long time, Chinese power supply is mainly on fossil-fuel. Regarding China Power's low carbon development, it's a major effort direction for speeding up the restructure of fossil-fuel power industry to low-carbon transition. During the "Eleventh Five-Year Plan", the significant progress of China fossil-fuel power on low-carbon development includes the followings: first, proportions of fossil-fuel installed capacity and fossil-fuel generating capacity reduced by 2.2% and 2.3% respectively compared to the year 2005. Second, the low efficient, high effluent 72 million small coal units were eliminated. Third, constructing clean and effective high-capacity coal units, so million kW-class ultra-supercritical coal power units in operation have reached 33, and the proportion of coal power units over 300 thousand kW in fossil-fuel installed capacity was from 47% in 2005 up to over 70%. Fourth, fossil –fuel power consumption rate declined. General effects of all the developments are that coal consumption for fossil-fuel power down to 335gce/kWh in 2010, which decreased by 35gce/kWh compared to 2005. It reached to the world level and achieved the goal of about 100 million tce energy conservation with a corresponding 300 million t-C02 carbon dioxide emissions.

(2) Low carbon development path of fossil-fuel power in 2020

Considering the general trend of the future China Power as well as referring to the "Eleventh Five-Year Plan" experience in the development of low-carbon electricity, low carbon development path of fossil-fuel power in the next ten years includes the followings: first, continuing to shut down inefficient coal units. Second, speed up constructing clean and effective high-capacity coal units. Third, it is to develop heat power plants. Fourth, it is to implement energy conservation generation dispatching and conduct electricity trade. Fifth, heat power plant should adopt energy conservation technologies and take management measures.

i) Keep on shutting down inefficient coal units

During the "Eleventh Five-Year Plan", it made a great contribution for the notable decline of the coal consumption and the elimination of the small-scale power plant. In China's present fossil-fuel installed units, the proportion of less than 300 million kW units is still close to 30%, a considerable part of which is the old inefficient and high effluent coal units. It will make an important contribution for energy conservation and reducing carbon dioxide emissions if inefficient coal units are closed.

ii) Speed up constructing clean and effective high-capacity coal units

In the next ten years, in order to satisfy the rapid growing electricity demand and replace the old ineffective coal units, Chinese government will still construct no less than 300 million kW fossil-fuel power units apart from developing hydropower, nuclear power, wind power and solar power. Moreover, the fossil-fuel power units will basically be the clean and efficient, high-capacity ultra-supercritical units and natural gas generating units, which will definitely lead to significant energy conservation effects.

iii) Actively developing cogeneration units

Take sub-critical 200MW units for example, heat power units coal consumption is equal to the ultra supercritical fossil-fuel units when the heating ratio is 30%. So heat power unit is an important way for low-carbon.

iv) Implementing energy conservation generation dispatching

Energy conservation generation dispatching means that it should prioritize scheduling high efficient and low emission units by unit energy consumption and pollutant emission levels from low to high sort on the premise of guaranteeing reliable power supply, in accordance with the energy, economic principles, in order to effectively reduce energy and resource consumption and pollutant emission. In recent years, Chinese government carry out a pilot project of five-province energy conservation generation dispatching in Guangdong, Guizhou, Sichuan, Jiangsu and Henan, which made positive progress and accumulated valuable experiences. Implementation of energy conservation generation dispatching will play an important role in fossil-fuel power industry.

v) Conducting electricity trade

Electricity trade is in principle generated power by efficient and environmental large-scale units substituting for those inefficient and high pollutant small-scale fossil-fuel units, that is, take low carbon energy such as hydropower and nuclear power replace fossil-fuel power units. In order to explore an effective way of promoting energy conservation using market mechanism, State Grid Corporation adopts various trades consisting of bilateral, centralized match and listing ways. State Grid Corporation actively develops the “large replace small” electricity trade through an open and transparent trading platform, which encourages that hydra power units and high capacity fossil-fuel power units should replace low capacity ones. The promotion of future electricity trade is predicted to play an improving role in energy conservation and emission reduction of fossil-fuel power industry.

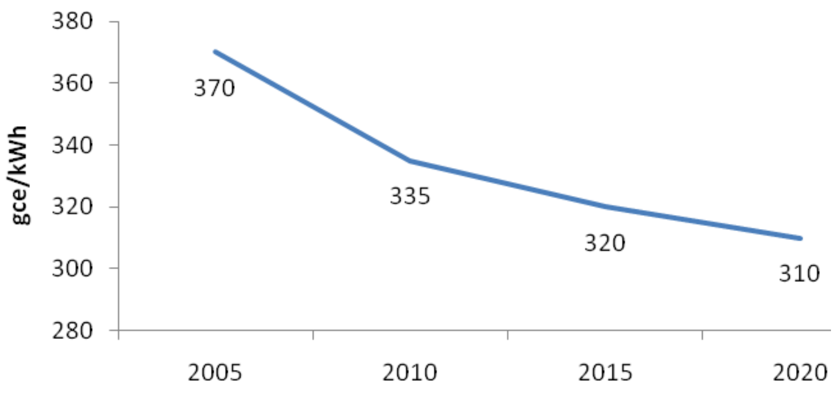
vi) Heat power plant should adopt energy conservation technologies and take management measures

Power plant itself is an energy-consuming industry, so an important way for the future low carbon development is to reinforce its energy conservation management as well as promote energy-saving technologies.

(3) Potential contribution of low carbon development in 2020

In the next ten years, fossil-fuel power industry might realize great energy conservation as well as make important contributions to carbon dioxide emission reduction through the above ways. Until the year 2020, it is predicted that fossil-fuel power supply will fall to 310gce/kWh, the proportion of coal generation installed capacity in state generation installed capacity will drop from 73.6% in 2005 to 60%, and proportion of natural gas generation units will increase to 3%. Fossil-fuel power industry may realize an energy-saving of 292 million tce compared with the year 2005, and the corresponding carbon dioxide emission reduction is 840 million t-CO2.

Figure 4-4: China fossil-fuel power supply coal-consuming downtrend from 2005 to 2020

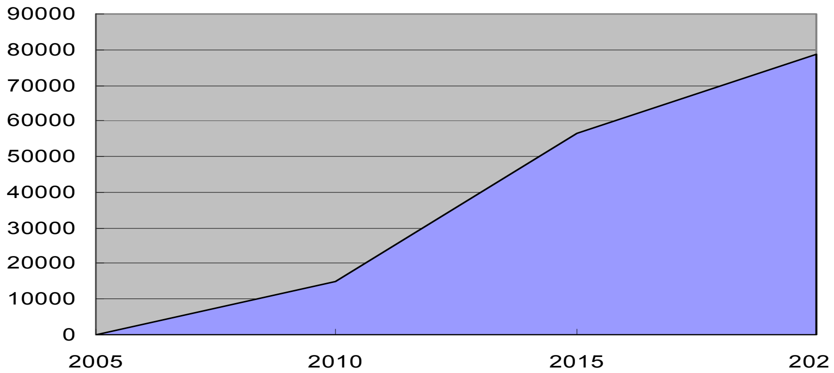


Source: LCIS Task Force analysis

(4) Analysis of low-carbon technology application potentials in thermal power industry by 2020

Low-carbon technology application is to play a key role in the low-carbon development of China’s thermal power industry. Currently, there are 18 major low-carbon technologies for power generation industry, i.e., ignition of gasified oil in coal-fired boiler, ignition of pulverized coal plasma particles in coal-fired boiler, dustremover, electric-bag composite dust-collector, flexible contact seal for air pre-heating in coal-fired boiler, intelligent soot-blowing and coking warning system in boiler, waste steam-heating and boiler starting system, waste heat recovery from flue gas desulfurization island and fan operation optimization, thermal power plant supervisory information system (SIS system), integrated flue gas heat recovery and optimization system, upgrading of steam turbine circulation, seal modification for steam turbine, cleaning device for condenser with spiral ties, operation optimization for steam turbine, energy-saving vacuum system, Ultra (ultra) supercritical thermal power generation, integrated gasification of coal-fired power generation, and fuel-gas-steam combined cycle. As analysis on those 18 important low-carbon technologies shows, if the technologies can be applied broadly to the expected proportion by 2020, 272 million tce can be saved annually compared with 2005, equivalent to an annual reduction of 7.8 billion tons of CO2 emission.

Figure 4-5: Potential CO2 reduction from application of 18 major low-carbon technologies in coal-fired power industry (2006-2020 – 10,000t CO_2)



Source: LCIS Task Force analysis

4.1.3 Policies and measures

1) China should strengthen energy and power generation plans, guide and promote the structural reform in power generation industry, widely apply power generation facility with large capacity and high parameters, and aggressively increase the proportion of renewable, clean and low carbon energy in the overall power-generation installed capacity. While improving thermal power plants, China should steadily promote the development of hydropower, actively develop nuclear power, and vigorously develop renewable energy, under the premises of protecting the ecological environment.

2) China should further shut down coal-fired power plants with small capacity, which is a very important way to save energy and reduce emission. China should forcefully implement relevant national industry policies, step up the efforts in shutting down small coal-fired plants, eliminate seriously polluting small fire-power plants while implementing co-generation reform. The shut-down efforts should be put ahead of building larger power plants, especially for those small plants in local SOEs, collectively owned enterprises and foreign owned enterprises. China should properly deal with the problems arising from the shut-down process, and provide relevant police support to affected enterprises.

3) China should further improve the energy-saving and emission-reduction mechanism, and incentives the power-generation industry to save energy and reduce emission through market mechanism. China should further implement price incentives, explore and improve adjusted tariff compensation for power plants with

energy-saving efforts, encourage development of low carbon energy and installment of large fire-power generators. China should explore CO2 emission trading system for the power generation industry.

4) China should promote the development and application of low-carbon energy technologies. To curb the consumption of fossil fuels and increase energy efficiency, China should optimize the development and application of low-carbon energy technologies in the field of clean coal, natural gas, renewable energy and low carbon energy, especially wind power and solar power, and explore carbon capture and sequestration technology. China should set out a road map and application strategy, combine independent R&D and introduction of foreign technology, and explore the path of low carbon energy development with Chinese characteristics.

5) China should promote application of major electricity-saving technologies. China should implement fiscal and tax incentives to lead power companies to implement major electricity-saving technologies and overhaul their energy conservation technologies.

6) China should effectively promote power-generation license trading reform. China should summarize current useful experience, identify existing problems, explore possible solutions, and carry on with effective implementation of power-generation license trading.

7) China should carry out energy efficiency and low-carbon regulation on coal-fired power plants. Such regulation is to guide coal-fire power plants to aggressively enhance their energy efficiency and green development.

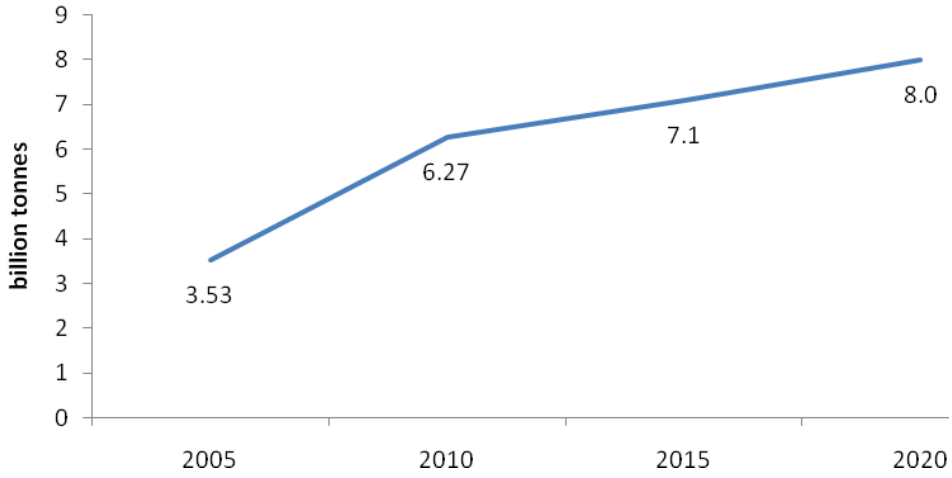
4.2 Steel Industry

4.2.1 The current situation and development perspective of the steel industry

Steel industry is an important pillar to China's national economy. During the "Eleventh Five-Year Plan" period, despite of the temporary impact by the global financial crisis, China's steel industry kept a strong growth record thanks to vigorous domestic demand. The production of crude steel has increased from 353 million tons in 2005 to 627 million tons in 2010, accounting for over 40% of the global crude steel production, an annual growth of 12.2%. China has become the largest steel producer of the world.

Currently, China's per capita steel production, storage volume and consumption are still lagging behind industrialized countries compared to the level during their peak era of Industrialization. In the next decade, China's on-going economic growth, population growth, Industrialization and urbanization will lead directly or indirectly to growing steel demand. There is still space for further development of steel industry. The production capacity will continue to grow, but with a much slower pace. China's crude steel production is estimated to be over 700 million tons by 2015, and reach 800 million tons by 2020. The annual growth during 2011-2020 is around 2.5%.

Figure 4-6: Production growth in China's steel industry 2005-2020 (100mt)



Source: LCIS Task Force analysis

4.2.2 Low carbon development path and potential contribution of steel industry

(1) Progress made in low-carbon development by steel industry during the "Eleventh Five-Year Plan" period.

China's steel industry is a typical energy intensive industry and a heavy CO2 emitter. In 2010, energy consumed by steel industry accounted for 13.3% of the overall national energy consumption. The staple fuel for steel industry is coal, making it the third largest CO2 emitter just ranking behind power generation industry and building materials industry. Low-carbon development is a major path for steel industry to achieve sustainable development. Many efforts have been made in that regard, including slashing energy consumption and promote circular economy. The most effective and practical effort is to enhance energy efficiency. During the "Eleventh Five-Year Plan" period, multiple energy conservation measures were practiced in steel industry, including elimination of outdated iron and steel making capacity, products mix adjustment, R&D on major energy-saving technologies, In particular, application of key breakthrough technologies such as continuous casting, pulverized coal injection in blast furnace, long-term maintenance of blast furnace, slag splashing of converter, localized production of rod and wire rolling, optimization of steel production process, improved energy management, etc. In 2010, comprehensive energy consumption of per ton steel production by medium to large steel enterprises has reduced from 741kgce/t in 2005 to 687kgce/t[92], a reduction of 7.3%. Energy consumption in various major production processes has been decreasing steadily, saving energy by about 32 million tce, and reducing CO2 emission by 80 million tons. In the development of circular economy, the compressive capacity of utilizing waste gas, water and residue has been strengthened. For instance, the comprehensive utilization rate of smelting residue is near 100%. All those progress has laid down a solid foundation for the low-carbon development of steel industry.

(2) Low-carbon development for steel industry by 2020

After years of exploration, China's steel industry has accumulated rich experience in low-carbon development. China can also draw useful lessons from international steel industries. In the next decade, low-carbon development of China's steel industry can be achieved from: elimination of backwards steel-making capacity, application of large-sized equipment, R&D on major energy conservation techniques, adjustment of products mix, acceleration of circular economy, rigorous energy management, etc.

i) Elimination of backward steel-making capacity

During the "Eleventh Five-Year Plan" period, steel industry has made remarkable progress in energy conservation and low-carbon development. Elimination of backward steel-making capacity has contributed heavily to this achievement. Under strong police incentives, vigorous steps have been taken in this regard, eliminating backwards iron-making capacity by 121.72 million tons, and backward steel-making capacity by 69.69 million tons. However, small-sized coking furnace, blast furnace, converter, electric furnace and rolling machine still account for a considerable proportion of the industrial capacity. Therefore, elimination of backward steel-making capacity is still a very important and effective way to achieve low-carbon development for steel industry. During the "Twelfth Five Year Plan" period, the industry is expected to eliminate backward iron-making capacity by 100 million tons, and backwards steel-making capacity by 22 million tons.

ii) Application of large-sized equipment

In China, the development level of steel enterprises is uneven, and their equipment sizes vary. Compared with large steel-making equipment, the small-sized equipment lacks environmental protection functions, which leads to heavy emission of dust and CO2, resulting in serious environmental pollution. Furthermore, such equipment consumes large amount of primary energy, and has a low rate of secondary energy recovery. During the "Eleventh Five-Year Plan" period, equipment in the steel industry has seen evident improvement. According to China Iron and Steel Association, by 2009, there are 456 sintering machine, among which 135 are larger than 180m2, 85 more than in 1995; 560 blast furnace, among which 189 are larger than 1000m3, 110% more than in 1995; 689 converters, among which 197 are larger than 100t. Notwithstanding, the proportion of medium to large-sized sintering machine, blast furnace and converter is still under 50% in the whole industry. There are still a large gap between China and advanced countries in the application of large-sized steel-making equipment. To increase the industrial proportion of large-sized equipment is still a basic path to achieve low-carbon development of the steel industry.

iii) R&D and application of major energy conservation techniques

Steel production is a energy intensive industry with large amount of energy consumption. In fact, 90% of greenhouse gas emission by China's steel industry is from fossil-fuel combustion. Therefore, R&D and application of energy conservation techniques to achieve higher energy efficiency, especially higher secondary energy utilization rate, is very important for low-carbon development of the steel industry. During the "Eleventh Five-Year Plan" period, many energy conservation measures have been practiced in the steel industry, such as coke dry quenching (CDQ), top gas pressure recovery turbine (TRT), fully continuous casting, slag splashing, combined cycle power plant (CCPP), sintering waste heat recycling, by-product gas recycling, regenerative combustion, etc. By the end of 2009, there are 340 mechanical coking furnace in major medium and large steel enterprises, equipped with 89 sets of CDQ devices, achieving a CDQ rate of 70%, 45% higher than in 2005. For blast furnace above 2000m3, the TRT device rate has achieved 100%, and for blast furnace under

1000m3, the TRT device rate is 96.3%. The converter gas recovery rate has increased from 50m3/t steel in 2005 to 88m3/t steel in 2009. However, the overall application rate of major available energy conservation techniques is low in the steel industry. There are still tremendous potential of energy conservation and emission reduction to be tapped. Innovation of low carbon energy saving techniques and broader application of existing ones is a practical way for the low-carbon development of steel industry.

iv) Adjustment of products mix

With upgrading of lower-end industries, the demand for steel products with high added-value is on the rise, especially for cold rolled sheets, H beam, high strength twisted steel, high magnetic oriented electrical steel, high-end car panels, and ultra supercritical high temperature and high pressure boiler steel. As the steel industry is expected to undergo faster structural upgrading in the future, it is important for the industry to produce more products with high added-value to reduce CO_2 emission of per unit added-value.

v) Acceleration of circular economy

The crude steel and waste steel storage in China is of a remarkable amount, providing a solid material foundation for the development of circular economy of the steel industry. As the *Development Policy for the Steel Industry* specifies, the steel industry should practice sustainable development and circular economy, enhance the capacity of environmental protection and comprehensive energy utilization, save energy while reduce consumption, and maximize the comprehensive utilization of waste gas, water and materials to achieve zero emission of waste gas, water and residue, all in a bid to establish circular steel plants. During the “Eleventh Five-Year Plan” period, Anben Steel Group, Panzhihua Steel Group Ltd., Baotou Steel Group Ltd., Jinan Steel Group Ltd., Laiwu Steel Group Ltd., Baoshan Steel Group Ltd., Taiyuan Steel Group Ltd., Ma’anshan Steel Group Ltd., Fujian Sangang Steel Group Ltd., Chongqing Steel Group Ltd., have carried out piloting programs to explore effective models of circular operation and industrial chain with other sectors to achieve circular energy utilization. In the future, circular economy in the steel industry will expand from piloting programs and be practiced more widely. It is an increasingly important way for the steel industry to achieve low-carbon development.

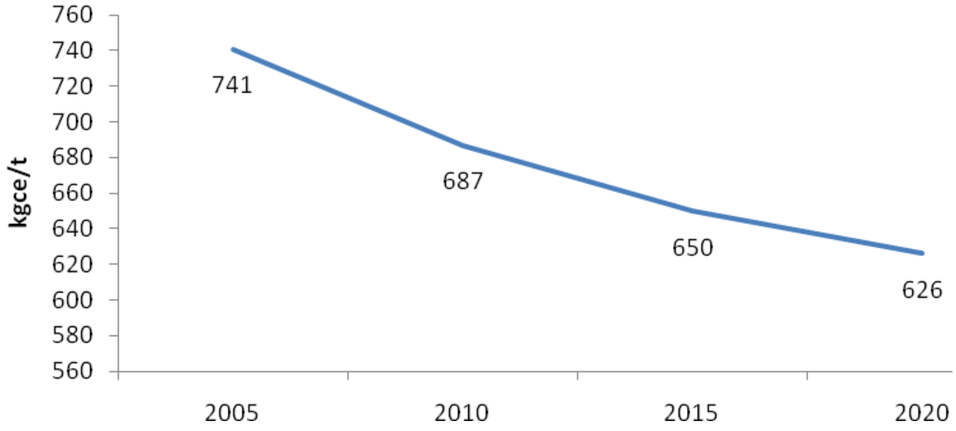
vi) Rigorous energy management

It is important for steel plants to establish rigorous energy management to realize low-carbon transition. Currently, Bao Steel has established a comprehensive energy management center, while An Steel, Wu Steel, Ben Steel, Tai Steel, Shang Steel First Plant, Mei Shan, Jiu Steel have developed functional energy management centers. The Ministry of Industry and Information Technology has made a specific request that all steel enterprises with an annual production capacity of over 3 million tons should establish energy management centers. In the next ten years, scores of steel companies are expected to establish energy management centers with comprehensive functions, which will constitute an important pillar to the low-carbon development of the industry.

(3) Potential contribution by low-carbon development of the steel industry by 2020

In the next ten years, with effective implementation of the above mentioned measures, the steel industry can achieve remarkable energy conservation and CO_2 emission reduction. By 2020, the comprehensive energy consumption of per ton steel by medium and large sized steel enterprises is expected to fall to 626 kgce/t, 115 kgce/t less than that in 2005. With evident reduction of energy consumption per ton steel, the steel industry can achieve an annual conservation capacity of 92 million tce by 2020 on the 2005 bases, equivalent to emission reduction of 220 million tons of CO2.

Figure 4-7: Potential energy intensity improvements in steel 2005 - 2020

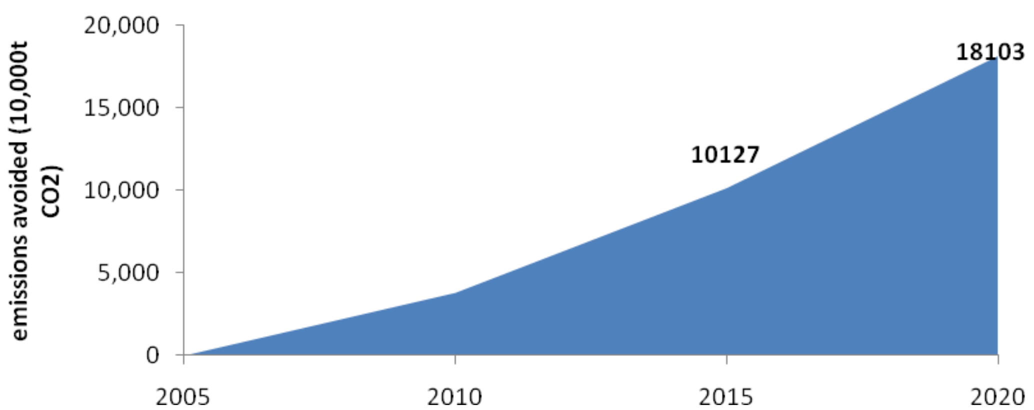


Source: LCIS Task Force analysis

(4) Analysis on low-carbon technology application potentials in the steel industry by 2020

Energy conservation and low-carbon technology application is very important for the low-carbon development of China's steel industry. Currently, there are 11 major energy conservation and low-carbon technologies for the steel industry, i.e., coke dry quenching (CDQ), coal moisture control (CMC), power generation by sintering waste heat, top gas recovery turbine (Dry TRT), combined cycle power plant (CCPP), blast dehumidification of blast furnace, blast furnace gas fired boiler, recovery and utilization of converter gas, regenerative combustion, energy management center, and submerged arc energy-saving furnace. As analysis on those 11 important technologies shows, if the technologies can be applied broadly to the expected proportion by 2020, 78.04 million tce can be saved annually compared with 2005, equivalent to an annual reduction of 182 billion t-CO2 emission.

Figure 4-8: Avoided emissions potential from application of 11 major energy conservation and low-carbon technologies in steel industry (2006-2020)



Source: LCIS Task Force analysis

4.2.3 Policies and measures

The major issues to be resolved in low-carbon development of the steel industry are: low industrial concentration; slow pace of structural adjustment; under-developed independent innovation capacity; inadequate exit mechanism for backward production capacity, etc. Governmental agencies have come up with policy measures to promote low-carbon transition of the steel industry, with the aim of fostering sustainable growth featuring low energy consumption, low pollution and low emission, and supporting China to transform from a large steel maker to a strong one.

1) Improvement of long-term mechanisms for energy conservation and emission reduction of the steel industry

The effective and sustained low-carbon growth of the steel industry depends on a comprehensive mechanism framework covering legal, administrative, technical and economic aspects. The environmental protection requirement should be vigorously enforced as the No. 1 consideration in steel project approval. All new steel projects (including upgrading and expanding of existing ones) should go to qualified professional agencies for energy conservation and emission reduction evaluation. Strict control should be practiced in granting access for new steel projects, and no green-light should be given to high energy consumption and heavy-polluting projects which have not meet the threshold requirement.

2) Establishment of effective monitoring systems for energy conservation and emission reduction

A one-on-one monitoring system should be established between regulatory agencies and enterprises, and the regulation process should be face-to-face. China should accelerate the development of on-line monitoring system, and make sure all major production sites of medium and large steel plants are equipped with on-line monitoring devices.

3) Improvement of price adjustment mechanism

China should enforce differentiated tariff and progressive water price to eliminate backward steel capacity. Punitive measures should be imposed on steel enterprises with excess energy consumption, such as highly progressive rates for power and water consumption, limited supply of power and water, etc. China should explore policy incentives of land transfer and outdated equipment disposal for steel enterprises to get rid of backward capacity, and provide transfer payment and subsidies for regions with heavy backward capacity to take transformation measures.

4) Faster elimination of backward steel capacity to foster industrial consolidation

The key for the steel industry to achieve low-carbon transformation is to accelerate elimination of backward capacity, promote industrial M&A, and strengthen industrial concentration. China should strictly enforce national and provincial requirements in energy conservation and emission reduction, design regional and yearly implementation plans to eliminate backward steel capacity. The plans should be formulated on the variety, quality, and M&A plans of relevant steel enterprises. China should concentrate resources to support high-end steel bases and upgrading projects, and foster M&A among small and medium sized steel plants. China should support the growth of large steel groups with cutting-edge techniques, high-end products, advanced large equipment, circular economic process and clean production environment.

5) Acceleration of technique innovation in steel production

China should lead and encourage steel enterprises to apply low carbon energy-saving and environmental protection equipment, new production techniques and new products through incentives such as government procurement and patent protection. Based on national and provincial technology centers, steel enterprises are encouraged to establish R&D centers for energy conservation and emission reduction. China should launch the implementation of major technologies and equipment demonstration projects to lead R&D and broader application of relevant technologies in the steel industry.

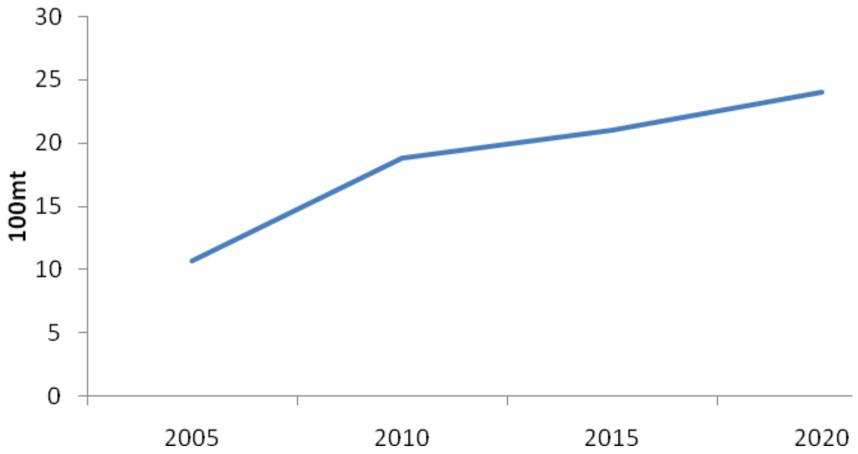
4.3 Building Materials Industry

4.3.1 The current situation and development perspective of the building materials industry

The building materials industry is an important sector for raw materials and manufactured products in China. During the "Eleventh Five-Year" period, with China's rapid economic growth, domestic demand for and export of building materials increased rapidly, fueling robust expansion of the industry. The average annual growth of cement production is 11.9%. In particular, plate glass, building and sanitary ceramics, glass fiber, glass steel and other building materials have seen remarkable output growth. In fact, the output of cement, plane glass, building and sanitary ceramics have ranked No.1 in the world for many years. Nearly half of all cement, plate glass and household sanitary ceramics in the world are produced in China.

In the future, as China's Industrialization and urbanization process accelerates, the expected output of various building materials will see various level of growth. The growth rate of cement production will slow down significantly. The cement production of 2015 and 2020 is expected to be around 2 billion tons and 2.1 billion tons, respectively.

Figure 4-9: Expected growth in China's cement industry 2005 - 2020



Source: LCIS Task Force analysis

4.3.2 Low-carbon development path and potential contribution of building materials industry

(1) Progress made in low-carbon development by building materials industry during the "Eleventh Five-Year Plan" period.

The building materials industry in China is a typical energy intensive sector and a heavy CO2 emitter. In 2010, energy consumption by the building materials industry accounted for 10% of the total national energy consumption. The energy structure of this industry is based primarily on coal and electricity; it is a second largest CO2 emitter only behind power generation industry. In its sub-sectors, cement manufacturing accounts for 70% of overall energy consumption of this industry, making it the largest CO2 emitter of the industry.

During the "Eleventh Five-Year" period, the building materials industry has made many efforts in exploring low-carbon transition, including: elimination of backward production capacity; promotion of key energy-saving and advanced techniques; vigorous energy management; circular economy development, etc. During this period, the building materials industry has made significant progress in low carbon development and energy conservation, the annual use of solid waste was over 600 million tons; the comprehensive utilization of fly ash and gangue facilitation accounted for 30% and 50% of the country total, respectively. Energy consumption of unit added-value, energy consumption of unit major building materials, and carbon dioxide emission intensity of unit added-value have decreased significantly. Energy efficiency progress and low-carbon development is particularly evident in the cement industry. 330 million tons of backward cement production capacity has been eliminated; new dry production process accounted for more than 70% of total cement output; power generation installed capacity by cement waste heat was 5 million kW; comprehensive energy consumption of cement production has reduced from 149.2 kgce/t in 2005 to 118.9kgce/t[93] in 2010, reduced by30.3kgce/t, saving energy by 57 million tce annually, equivalent to annual CO2 emission reduction of 135 million tons.

(2) Low-carbon development path for building materials industry by 2020

As one of China's major energy-intensive and high-emission sectors, the building materials industry has always been the focus of energy-saving and emission reduction efforts. Currently, a prominent problem in the low-carbon efforts of building materials industry is low industrial concentration. For instance, the industrial concentration of cement-making and plate glass-making are both under 40%. Energy conservation, clean and low-carbon development is a daunting task faced by the building materials industry. In the next decade, low-carbon development of the building materials industry will be achieved through the following major efforts, including: speeding up scientific and technological progress, vigorously promoting the application of advanced energy-saving technology, techniques and equipment; adjusting and optimizing the industrial structure; implementing clean production process; enhancing comprehensive energy utilization; fostering development of circular economy; and strengthening scientific management.

i) Adjustment and Optimization of Industrial Structure

Adjusting and optimizing the industrial structure will be a major way for the building materials industry to speed up low-carbon transition. Firstly, backward production capacity should be eliminated. 300 million tons of backward cement production capacity and all glass-making capacity using horizontal sheet process is expected to be eliminated during the "Twelfth Five-Year Plan" period. Secondly, strict control should be applied to energy efficiency and emission of new building materials production capacity. Thirdly, emphasis should be placed on the development of sub-sectors with low energy intensity, low emission and high added-value, including: deep processing for cement and glass; modern windows and doors, household kitchen units, bathroom units and roof materials. To cater to the needs of the emerging energy sector and other strategic industries, China should promote the development of new inorganic non-metallic materials and products, as well as sophisticated processed materials and products of non-metallic mineral.

ii) Broader application of low carbon energy-saving techniques, technology and equipment

Broader application of low carbon energy-saving techniques, technology and equipment in the building materials industry, particularly the comprehensive waste heat recovery technology, will be an effective way to promote low-carbon transition. The cement industry should improve the existing dry cement-making process; apply high-efficiency clinker burning system and powder equipment, integrated optimization and other online control technology and equipment to reduce energy consumption in clinker and cement production, and to cut carbon dioxide emissions. By the end of the "Twelfth Five-Year Plan" period, waste heat power generation rate in cement-making and glass-making production lines will reach 80% and 30%, respectively.

iii) Acceleration of Circular Economy

Development of circular economy is an effective way for the building materials industry to achieve low-carbon transition. The building materials industry is an important node in the chain of China's circular economy; its utilization of solid waste, in particular industrial solid waste, plays a significant role. At present, the research and practice of using cement kiln to dispose municipal solid waste have made significant progress; and R&D has been launched on the production of building materials by using construction wastes. The building materials industry has a very important role to play in the comprehensive utilization of waste in the future. The building materials industry has much to contribute in the coordinated disposal of industrial waste, municipal waste, sewage sludge and construction waste. It should have the capacity to turn waste into wealth, and at the same time, realize energy conservation and CO2 emission reduction.

iv) Vigorous energy management

To strengthen energy management is also an important way to accelerate low-carbon transition of the building materials industry. During the "Eleventh Five-Year Plan" period, cement enterprises have made positive progress in energy efficiency benchmarking management, which played an important role in promoting low-carbon transition of the cement industry. During the "Twelfth Five-Year Plan" period, the cement industry should speed up R&D on smart production and information management system, and establish energy and resource consumption management platform. Dozens of cement companies are expected to build energy management centers, which will play an important role in improving energy management and expanding energy-saving and emission reduction capacity.

(3) Potential contributions by the low-carbon development of the building materials industry by 2020

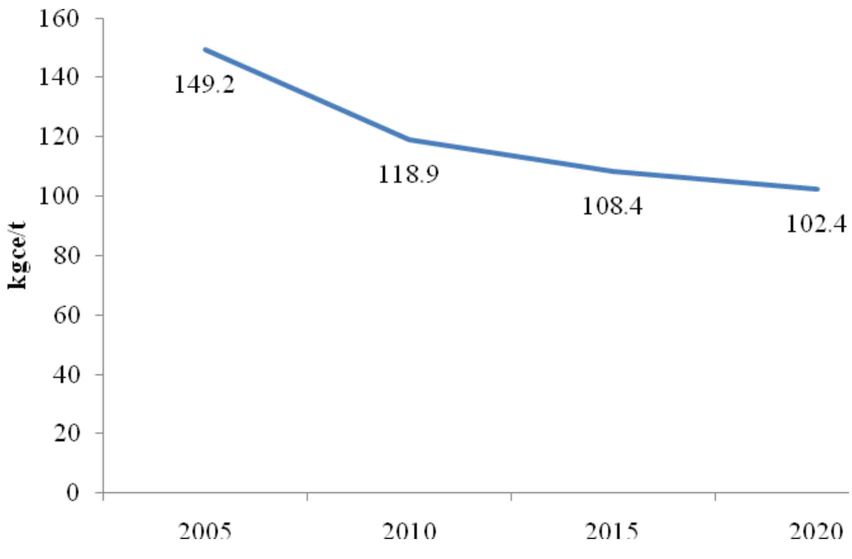
If the above measures are implemented in the building materials industry over the next decade, significant contribution can be made in energy conservation and CO2 emission reduction. By 2020, the main building materials, including cement, plate glass, construction ceramics and sanitary ceramics, will seen their comprehensive energy consumption decline evidently compared with in 2005, and the carbon dioxide emission of unit added-value will be significantly reduced. Among the sub-sectors, cement industry is expected to make outstanding contributions to low-carbon development. By 2020, comprehensive energy consumption of per unit cement will be reduced to 102.4kgce/t, 46.8 kgce/t less than in 2005, which constitutes a annual conservation capacity of 98.28 million tce, equivalent to a reduction of 234 million tons of CO2 emission.

(4) Analysis of low-carbon technology application potentials in building materials industry by 2020

Energy conservation and low-carbon technology application is to play a major role in the low-carbon development of China's building materials industry. Currently, there are 15 major available energy-saving and low-carbon technologies for building materials industry, i.e., power generation by low-temperature waste heat, high-efficiency powder screening, roller grinding, vertical roller grinding, multi-channel combustion, cement clinker cooling by steady-flow system, power generation by waste heat from glass-making furnace, oxygen-fuel combustion, oxygen-enriched combustion, HFKH rapid drying, vertical cement kiln, Low-E glass-making, fired perforated bricks and EPS fired hollow bricks, energy-efficient synthetic resin curtain wall system, and premixed secondary combustion.

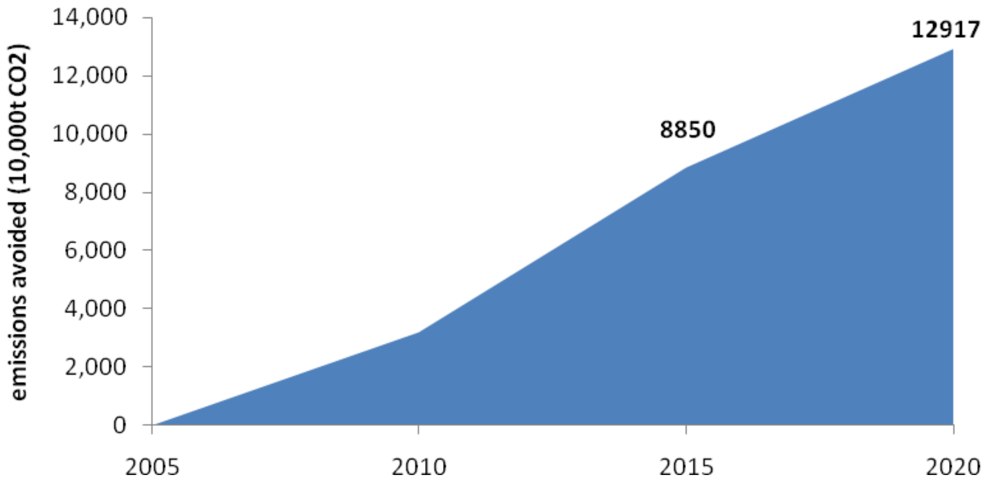
As analysis on those 15 important technologies shows, if the technologies can be applied broadly to the expected proportion by 2020, 55.69 million tce can be saved annually compared with in 2005, equivalent to an annual reduction of 136 million tons of CO2 emission.

Figure 4-10: Potential energy intensity improvements in cement industry 2005 - 2020



Source: LCIS Task Force analysis

Figure 4-11: Potential CO2 avoided with application of 15 major low-carbon technologies in cement industry (2006-2020 – 10,000tCO_2)



Source: LCIS Task Force analysis

4.3.3 Policies and measures

Currently, building materials industry faces following major problems: low industrial concentration, slow structure adjustment, inadequate innovation, slow spread of new technologies, and backward exit mechanism for outdated production capacity, insufficient use of resources and poor energy management. Concerned government departments should formulate polices on energy saving and emission reduction, and promote clean and low-carbon technologies so as to achieve sustainable development.

1) Enhance the supervision on energy saving and emission reduction.

Government agencies in charge of energy efficiency and emission reduction should strengthen their supervision on big energy consumers and emitters; enhance their management of energy utilization, measuring instruments allocation and target responsibility assessment. They should set up and improve the systems for statistics compiling, monitoring and assessing. Stricter access conditions for cement industry must be laid down: the faster the measures for project assessment are made, the more blind extension projects will be avoided. In addition, government should improve its subsidy mechanism for the exit of backward production capacity.

2) Set up a new mechanism of energy saving and emission reduction; issue favorable policies.

Encourage energy management companies (EMCs) to provide technology application services including energy audit, engineering service, energy performance contracting(EPC) and project finance. Guide enterprises to participate in power demand side management to control pollution and achieve systematic energy efficiency. Issue favorable policies to promote waste recycling, upgrade waste management system, straighten out channels of pollution sources. Specialize refuse collecting and disposal. Facilitate the development of waste pretreatment industry.

3) Improve the standard system for energy efficiency and emission reduction.

Give full play to research institutes and standardization committees to set up technology standards for cement, glass and other industries, establish comprehensive systems for the standard of limited quantity and the standard for monitoring, examination and certification. To put it more specifically, that is: to fasten the establishment of CO_2 calculation system and the evaluation system for energy intensive units such as cement kiln; update the standard system for resource comprehensive utilization; intensify the supervision on efficiency benchmarking, encourage industry associations to carry on with their achievements made in benchmarking to strengthen the technical guidance on enterprises.

4) Support the technological innovation of building materials industry.

Promote the establishment of state-level research institutes and the cross-industry innovation system which integrates production, teaching and research. Add the input on technology retrofit, especially generic technologies and engineering applications to crack down key problems in environmental protection. Encourage building materials manufacturers to raise energy efficiency by localizing and scaling up the cement production equipment which is high efficient, energy saving and environment friendly. Provide favorable tax refund policies for building materials equipment.

5) Build up the energy saving capacity of enterprises.

Identify corporate responsibilities on energy saving and emission reduction, and reinforce the establishment of management system. Building materials enterprises should designate positions responsible for energy management, and clarify target assessment requirements. Corporations should conduct trials actively to promote energy management capacity. At the same time, they should, according to the requirements of statistics, monitoring and assessment, improve the system of online monitoring and analysis so as to enhance efficiency management.

6) Give full play to industry associations and other intermediary organizations.

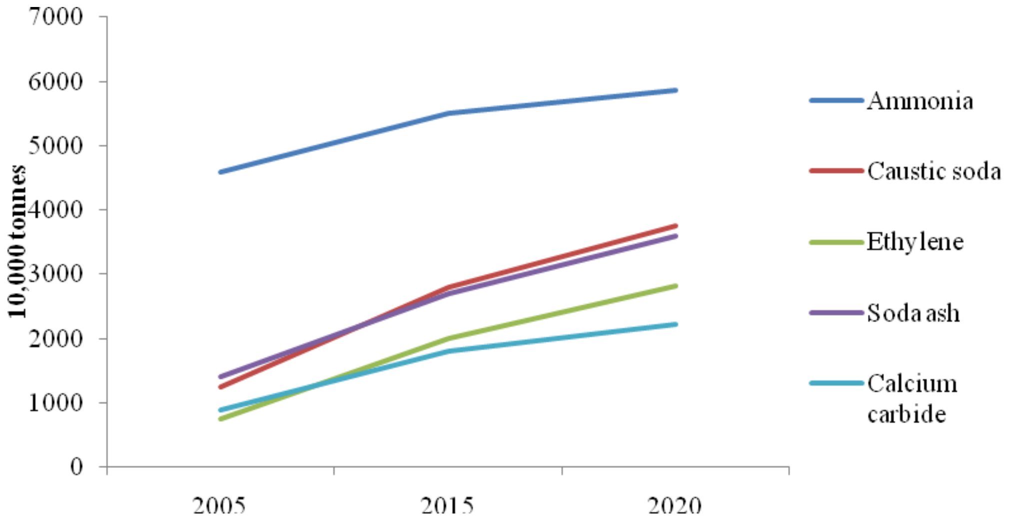
To bring industry associations and other intermediary organizations into full play, government agencies should support associations on the research in energy efficiency, data collecting, statistics and analysis; at the same time, intermediary organizations should accelerate the communication on technologies and products in building materials industry.

4.4 Petrochemical industry

4.4.1 The status quo and development trend of petrochemical industry.

During the 11^{th} five year plan, China's petrochemical industry grows at more than 20% annually. Currently, China is the second producer of oil and chemical products in the world. Its output of more than twenty petrochemical varieties rank among the highest, e.g. the turnout of nitrogen fertilizer, phosphate fertilizer, calcined soda, caustic soda, sulphuric acid, calcium carbide etc ranks at the first; ethylene, synthetic resin and synthetic rubber, second; crude oil, fifth.

Figure 4-12: Expected growth in China's petrochemical production 2005 - 2020



Petrochemical industry in developed countries has passed its peak, but in China, it is booming. The rigid demand of oil products such as oil products, fertilizer and pesticide will remain there for as long as a decade, and the demand of petrochemical products at the high-end markets are enormous, so the turnover of these products will register their respective high growth. By 2020, the outputs of synthetic ammonia, calcined soda, caustic soda, calcium carbide and ethylene are expected to reach 58.74 million tons, 35.93 million tons,37.57 million tons,22.16 million tons and 28.19 million tons.

4.4.2 The development path and potential of low carbon in petrochemical industry.

(1) The development of low carbon in petrochemical industry during the 11^{th} five year period.

Compared with other industries of China, energy consumption of petrochemical industry is high, accounting for 13% of China's total. Eight of its sub-industries such as crude oil processing, nitrogen manufacturing and organic chemical material manufacturing are big energy consumers, accounting for 85% of the total. In petrochemical industry, the energy consumption mix is dominated by raw coal and coke, about 50% of the total; electricity and natural gas comes second.

During the 11the five year period, the exploration of low carbon at petrochemical industry has been pushed forward. In 2010, the energy consumption per unit dropped by more than 10% compared with 2005; energy saved from crude oil, ethylene, and synthetic ammonia, calcined soda, caustic soda, calcium carbide and yellow phosphorus surpassed 10million tce, tantamount to 25 million tons of CO2 reduction.

(2) Petrochemicals development path by 2020

China's petrochemical industry is the key area for energy saving and emission reduction. It faces the following major challenges in terms of low carbon development: low industry concentration, irrational industry structure, inadequate technological innovation and coal-dominated energy consumption mix. In the coming decade, ways to promote low carbon include: improving the efficiency of newly-added production capacity; eliminating backward production capacity; developing and promoting energy saving and low carbon technologies; speeding up restructuring; developing circular economy; enhancing corporate energy management.

i) Improve the energy efficiency of newly-added production capacity and eliminate backward production capacity.

Energy efficiency improved in the newly added production capacity combined with the backward production capacity eliminated contribute to more than 80% of the 10 million plus tce of energy saved from 2000 to 2005. Therefore, this method for saving energy should be carried on as the key to low carbon.

ii) Speed up restructuring.

Restructuring is another way towards low carbon. This is a multi-layered process: adjusting the structure of sub-industries, products and raw materials, whereas the first task—sub-industry restructuring—is the main task. To achieve that, China needsto: develop high-end chemical products and the petrochemical products which are now limited in supply; at the same time, lower the proportion of low-end and primary products with high energy consumption, high emission and low added value.

iii) Develop and promote energy saving and low carbon technologies.

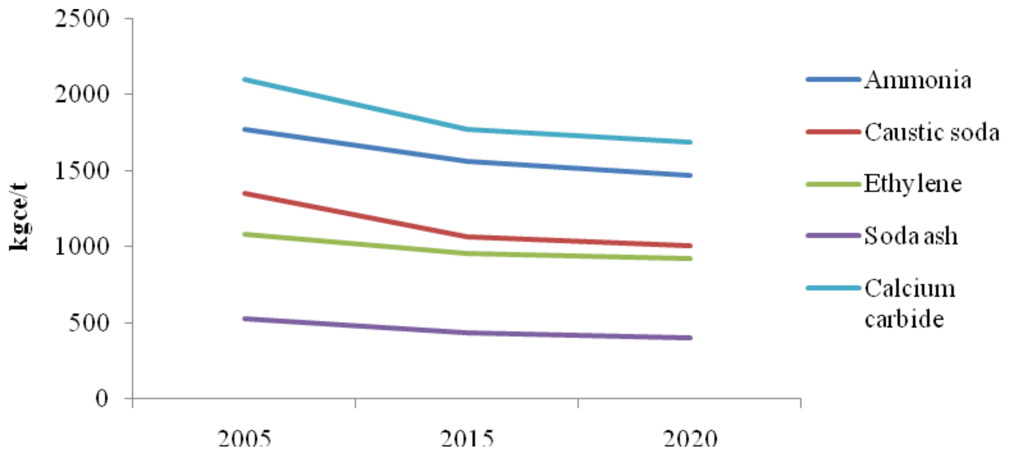
Technology development and promotion is an effective way towards low carbon. It saves energy and reduces emission through generic technologies for clean production, resource conservation, product deep processing etc, and through technology retrofit in traditional areas such as oil refining, fertilizer, pesticide, chlor-alkali and calcined soda.

iv) Develop circular economy.

Circular economy is a new path to low carbon. Next, petrochemical industry will strengthen resource conservation, transform waste into resources, develop energy cascade use and recycle energy, e.g. recycle and reuse industrial sewage and solid waste. Circular economy aims to reduce carbon dioxide and other waste in the production process.

(3) Potential contribution of low carbon by 2020.

Figure 4-13: Potential improvements in energy intensity of petrochemical products in China 2005-2020

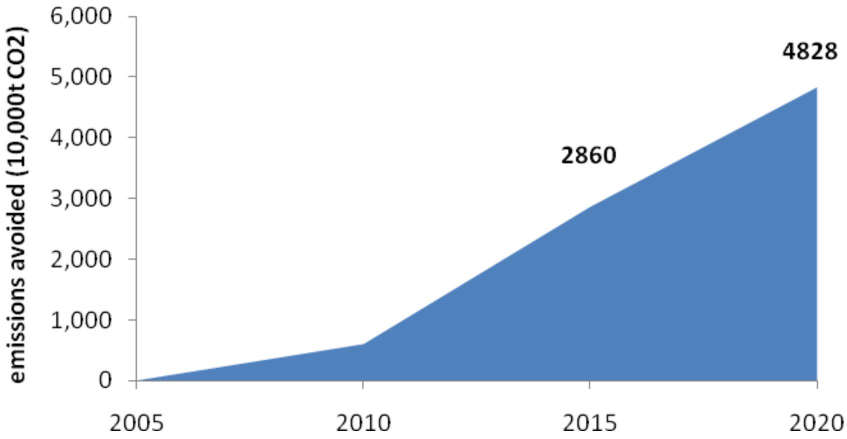


Source: LCIS Task Force analysis

If the above mentioned methods are put into practice in the next decade, a great amount of energy will be saved and generous CO2 emission will be reduced. By 2020, energy consumed by ethylene, synthetic ammonia, calcined soda, caustic soda and calcium carbide will drop by 48.89 million tce each year, tantamount to the annual reduction of 116 million tons of CO2.

(4) Analysis on the potential of low carbon technology by 2020

Figure 4-14: Potential CO2 avoided with application of 17 major low-carbon technologies in petrochemicals industry (2006-2020 – 10,000tCO_2)



Source: LCIS Task Force analysis

When China's petrochemical industry is turning towards low carbon, some energy saving and low carbon technologies will take great effect. There are 17 key technologies: environment-friendly production of Calcium Carbide, surplus heat utilization in the production of carbon black and power generated by end gas, recycling of low-temperature potential energy by large and medium sized sulfur-based sulfuric acid plants, energy conservation in ammonia production, recycling of ethylene from catalytic dry gas through pressure swing adsorption, ion-exchange membrane caustic soda, membrane polar distance ionic membrane electrolysis, new full fluid phase hydrogen-added technology, thermal integration of gas fractionation plant and technology for the utilization of low temperature heat, Pervaporation Membrane Separation Technology, incrustation removal of ultrasonic techniques in heat exchangers, water solution total-cycling urea energy-saving process, utilization of the waste heat from hydrogen chloride synthesis, energy saving by molecular sieve in ammonia synthesis loop, the utilization of heat energy evolved from thermal-process phosphoric acid production, air preheater in cracking furnace, three-effect countercurrent falling-film evaporation technology. Analysis on the 17 technologies proves that as long as they are promoted as expected, by 2020, 20.8 million tce of energy will be saved each year, tantamount to the annual CO2 reduction of 48.28 million tons.

4.4.3 Policies and measures

1) Promote technological innovation, localize and scale up equipment manufacturing.

It is advised that the central government should arrange a special fund for studying and promoting key and generic technologies for energy saving, emission reduction, clean production, resource conservation, comprehensive utilization and products deep processing.

2) Support the development of high-end fossil fuel products and optimize product structure.

To advance the technology and techniques in some key areas such as fine chemistry, bio-chemical industry, new chemical materials, coal chemical industry and agrichemicals, government should set up a special fund for technological retrofit, and delegate industry associations to evaluate the projects before hand.

3) Intensify macro control to promote energy saving and emission reduction within industry.

Government should set up laws and regulations, adopt economic, fiscal, and executive methods, taxation policies as well as technological and environmental standards, especially compulsory and reach energy efficiency standards, to curb the waste in petrochemical industry.

4) Complete exit mechanism, and fasten the elimination of backward production capacity.

It is advised that the government should map out and regularly update the catalog for backward production capacity. Central and local government should set up special funds to compensate logged out enterprises and their staff so that the backward companies would make their exit voluntarily. As for those companies which turn to projects that are in line with national policies, they will receive support in terms of administrative examination, land and finance. Executive interference must go with market force to phase out backward production capacity. Government should lead and delegate associations to control hot investment, nail down stricter access conditions to curb capital inflow to excessive production capacity.

5) Encourage some energy intensive fossil products to transfer their production overseas.

Currently, energy intensive products such as urea, ammonium phosphate, calcined soda, tires and chlor-alkali are surplus in our country, but competition in these areas remains fierce. If government could set up a special fund and spirit up enterprises to seize the chance to go international and transfer to resource-abundant places, China can, on the one hand, increase international market shares, on the other, reduce national energy consumption and CO2 emission.

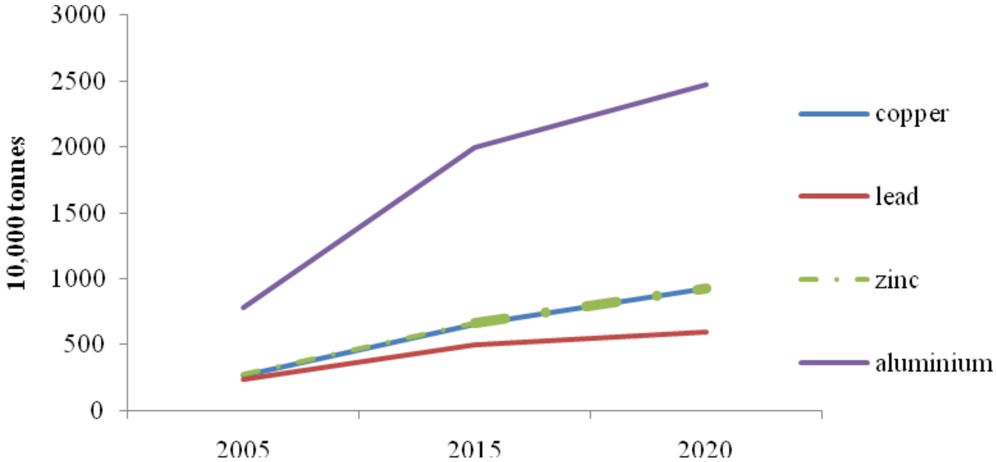
4.5 Non-ferrous Metal industry

4.5.1 The status quo and the development trend of non-ferrous metals industry

During the period of "Eleventh Five-Year Plan", robust domestic demand for non-ferrous metals from many industries such as construction, electronics, electrical, mechanical manufacturing drives a rapid growth of China's non-ferrous metals industry. In 2010, China’s ten non-ferrous metal production volumes totaled 31.35 million tons, of which 4.574 million tons are refined copper, 16.195 million tons are primary aluminum, 419.9 tons are lead, 5,164,000 tons are zinc, 171,000 tons are nickel, 149,000 tons are tin and 187,000 tons are antimony.

In the next decade, the government will further discourage the industries with high consumption of energy, heavy pollution and strong demand for resource, so it will implement measures such as adjusting export tax rebate and tariff, highlighting energy-conservation and emission reduction, implementing resource tax etc. The measures will end the period of breakneck growth of non-ferrous metal industry and usher in a period of steady growth. By 2020, according to estimation, the total production volume of the 10 non-ferrous metals in China will hit 42 million tons, of which copper accounts for 9.25 million tons, lead 595 million tons, zinc 926 million

Figure 4-15: Projected production of non-ferrous metals 2005-2020



(1) Progress in low carbon development of non-ferrous metal industry during the period "the Eleventh Five-Year Plan"

The energy consumption of non-ferrous metal industry accounts for 4% of the national total. In the energy consumption mix, coal and electricity takes up 87% and coke, gasoline, diesel etc takes up 13%.

During the period "the Eleventh Five-Year Plan", non-ferrous industry has adopted measures to save energy and cut carbon emission. This measures were as follows: phasing out of pre-baked anodes tank and replacing it with 160kA tank year by year; actively eliminating backward facilities for refining copper such as blast furnace, electric furnace and the reverberator; developing and promoting cell shut-off and restart-up with power technology, three degree optimization technology, holographic technology, aluminum liquid refining optimization technology graphitized cathode blocks technology, Bayer Process Stripping technology, fluidization calcinations for aluminum hydroxide technology, copper flash smelting furnace technology, oxygen bottom blowing - hot lead slag reduction flash smelting of lead technology, magnesium smelting by low carbon energy (furnace gas, coke oven gas, semi-coke gas, natural gas, gas), regenerative combustion technology, lime Bayer process, the vertical reducing furnace heat storage tank, high falling film evaporator, large-scale mining equipment, and efficient grinding equipment, efficient settlement trough, deep cone sedimentation tank and other new technologies, new processes and new equipment of energy-saving.

The government also vigorously promoted circular economy. It has implemented the benchmarking management of energy efficiency in industrial organizations of copper, aluminum, lead, zinc, magnesium, etc. During this period, the non-ferrous metal industry has made significant progress in saving energy and pursuing low-carbon development, for it cut the per unit added energy consumption by about 19% and slashed the energy consumption of the main non-ferrous metals, among which the aluminum integrated AC consumption is low enough to be a world leader. From 2005 to 2010, the saved energy of non-ferrous metals sector has exceeded 10 million tons and the reduction of carbon dioxide emission was about 25 million tons.

(2) The Low Carbon development Solutions for Non-ferrous Metals in 2020

Learning from the experience of energy saving and low-carbon development during the period of "the Eleventh Five-Year Plan," solutions for China's non-ferrous metals industry's low carbon development are as follows: more vigorously eliminate backward production capacity, develop and promote new technologies, new processes and new equipment for energy-saving, speed up structural adjustment, boost the recycling of secondary metals and step up the energy management in enterprises.

i) Phase out backward production capacity

More vigorously phrasing out backward production capacity will be a major solution for the low-carbon development of non-ferrous metals industry. In accordance with the requirements of energy-saving management departments of the central government, for the period of "the Twelfth Five-Year Plan ", non-ferrous metal industry will phase out of 100 kA-and-below small pre-baked aluminum tank, eliminate smelting furnace, electric furnace, reverberatory furnace and other cooper smelting technologies and equipments, sintering pot , sintered plate, simple lead smelting furnace and other backward lead refining technologies and equipments; sintering lead smelting process without proper acid and gas absorption system, backward technologies such as using a muffle furnace, manger furnace, horizontal tank, vertical small tank (with daily production less than 8 tons per day) etc for roasting, using simple condensation and cooling facilities for powder-collecting and other backward production techniques and equipments for producing zinc or zinc oxide products.

ii) Develop and promote new technology, new techniques and new equipments

Developing and promoting of energy efficiency and low carbon technologies will be an effective solution for non-ferrous metal industry to achieve low-carbon development. In the coming decade, non-ferrous metal industry will focus on the development and promotion of energy efficient mining technology and equipment, self-heating enhanced smelting and electrolytic processes, equipment and automatic control technology, energy-saving hydrometallurgy technology, aluminum alloy casting solution prepared by direct continuous billet , Casting slab, non-ferrous metal processing energy-saving technology, and efficient combustion technology. Aluminum smelting will focus on the development and promotion of new electrolytic aluminum reduction cell cathode flow channel and a low carbon energy efficient aluminum structure technology, large aluminum reduction cell with high anode current density technology, efficient low-temperature electrolytic technology, high-quality energy saving anode and new cathode, the optimization of bauxite flotation and de-silicon technologies and equipments, efficient pharmaceutical processing bauxite refining, efficiency and energy saving technology for alumina production from low-grade bauxite, Bayer efficient separation of high concentration slurry leaching technology and high decomposition production technology, semi-dry and dry-firing technology, separation of high concentration of fast liquid-solid by sintering technology, heat recovery during alumina production process technology and so on.

iii) Step up restructuring

In the future, non-ferrous metal industry will accelerate structural adjustment, strictly implement industry access standards and control the blind expansion of low efficiency and high carbon emissions production capacity. Non-ferrous metals enterprises will undergo reforms in many ways, such as trans-regional restructuring, inter-regional, restructuring with upstream and downstream of the industry chains, and cross-industrial restructuring with mining and power enterprises, to achieve scale and group management, improve industry competitiveness and cut carbon dioxide emissions. The adjustment will be crucial for aiding non-ferrous metal industry to speed up its transition towards a low-carbon development.

iv) Improve the recycling of secondary metal

Secondary metal recycling is another major solution for future low-carbon development of non-ferrous metals industry. During the period of "the Eleventh Five-Year Plan", with China's rapid development of non-ferrous metal recycling industry, recycling technology and equipment have been notched up; major secondary non-ferrous metal production in 2010 exceeded seven million tons, accounting for about 23% of non-ferrous metal production, which equals to a consumption reduction of over 10 millions of standard coal or around 30 million tons of carbon dioxide by primary metals. In the next ten years, non-ferrous metal industry will vigorously develop secondary metals imports processing parks and secondary metal utilization industries, strengthen the comprehensive utilization of resources, innovate models, create a new system of recycling non-ferrous metal industry and improve the utilization level of recycled metal. It is estimated that by 2015, the main secondary metal production would add up to 11.1 million, of which 380 million tons are recycled copper, 580 million tons are recycled aluminum and 150 million tons are secondary lead. Secondary refined copper, secondary aluminum and secondary lead will account for over 58%, 29% and 30% of the production of refined copper, electrolytic aluminum and refined lead. By 2020, secondary metal recycling capacity will reach 12.4 million tons.

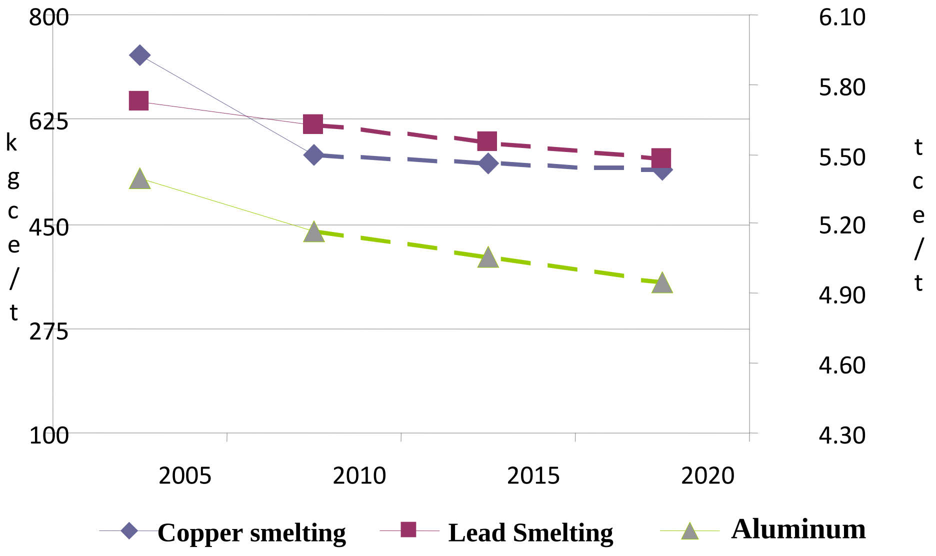
v) Strengthen energy management in enterprises

Strengthen energy management in enterprises is essential for the low carbon development of non-ferrous metals industry. It is estimated that non-ferrous metal industry will further promote energy efficiency benchmarking management, strengthen the energy saving and emission reduction management in the key enterprises and key non-ferrous metals varieties.

(3) The potential contributions of low-carbon development in non-ferrous metal industry in 2020.

In the coming decade, non-ferrous metal industry will promote energy conservation and emission reduction through the various channels mentioned above and is expected to achieve significant energy and resource conservation making important contribution to carbon emission reductions. By 2020, energy consumption of the ten non-ferrous metals is expected to continue to decrease, forming a energy saving capacity of about 25 million per year compared with 2005, equivalent to a carbon dioxide emission reduction capacity of about 60 million tons; Among them, decrease in overall energy consumption of aluminum will account for about 80% of the potential contribution for carbon dioxide emission reduction. In addition, compared with 2005, the recycling of secondary metal will amount to 20 million tons of primary metal production volume, with a corresponding reduction of 50 million tons in carbon dioxide emissions.

Figure 4-16: Energy intensity of China's major non-ferrous metals 2005 to 2020

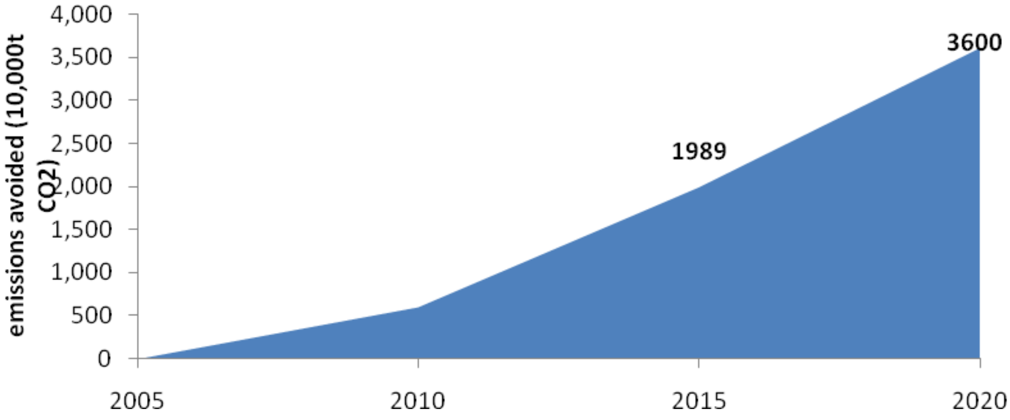


Source: LCIS Task Force analysis

(4) Analysis of the potential of low-carbon technologies' popularization and application in non-ferrous metal industry in the year 2020.

As China's non-ferrous metal industry is going green, the popularization and application of energy conservation and low-carbon technologies are expected to make significant contributions. Currently, there are nine major technologies for energy-saving and low-carbon adopted in China's non-ferrous metal industry. They are as follows : oxygen enriched bottom-blowing copper smelting technology, the technology of intensifying electric current in pre-baked aluminum smelting cell and highly efficient energy-saving, new cathode structuring in aluminum cell and the operation and control technology of baking, and lead flash smelting technology (including one-step lead smelting), the technology of direct reduction of liquid lead slag, the technology of pressure and oxygen-rich directly leaching of zinc, zinc oxidizing ore and efficient and clean metallurgical technology of second-used resources, energy-saving technology of restoring the system by combusting magnesium in high temperature and large pneumo-mechanical flotation machine. The analysis of the 9 technologies tells if China popularize and use them timely according to pre-fixed proportions, then China can save around 14.34 million tce of energy-saving capability by 2020, which means the reduction of CO2 emission capacity equals the reduction of 36 million tons of CO2 the emission in the terms of 2005 consumption level.

Figure 4-17: Potential avoided emissions with application of nine major technologies for energy-saving and carbon-cutting in non-ferrous metal industry (2006-2020)



Source: LCIS Task Force analysis

4.5.2 Policies and measures

1) Create more favorable fiscal and tax policies to support R&D and application of key and common technologies for energy-saving and low-carbon in non-ferrous metal industry.

China suggest competent government departments should unveil more favorable fiscal and tax policies to support R&D and application of key and common technologies for energy-saving and low-carbon in non-ferrous metal industry. To be more specific, they should list key technologies in the industry such as aluminum smelting, continuous smelting of copper and lead, and flash and one-step smelting of lead, copper, and nickel as major national science and technology programs, support R&D of high value-added materials processing, and high-end products, list the technology of processing and manufacturing of high-performance copper alloy materials, intensive processing of tungsten and carbide alloys, the research and development of high-end products as national major science and technology programs, support to the researching and manufacturing of key facilities for production in non-ferrous metal industry to increase their independent research and manufacturing capabilities, highlight the strategic importance of metals like tungsten, tin, antimony, molybdenum, indium, rare earth, support the exploration of high-performance material, research and manufacturing of high value-added products to translate resource abundance into industrial and economic competitiveness and offer incentives such as financial support and tax relief for energy-saving programs in non-ferrous metal industry.

2) Establish and improve the incentives mechanisms for energy-saving in non-ferrous metal industry

Since production of some non-mental is a main source of revenue for county-level governments, they must be reluctant for structural readjustment and phrase out for backward production facilities. Therefore, China needsto establish and improve incentive mechanisms for energy-saving in non-ferrous metal industry. First, China should, in accordance with relevant national policies, allocate the funds from the central government to reward or subsidize non-ferrous metal industrial enterprises which have excelled at energy-saving. Secondly, China should offer an appropriately give income tax relief to those non-ferrous metal enterprises which have met the target of energy-saving and emission according to the principle of “more tax relief for more energy conservation”.

3) Give full play to industry associations in promoting energy-saving in the industry.

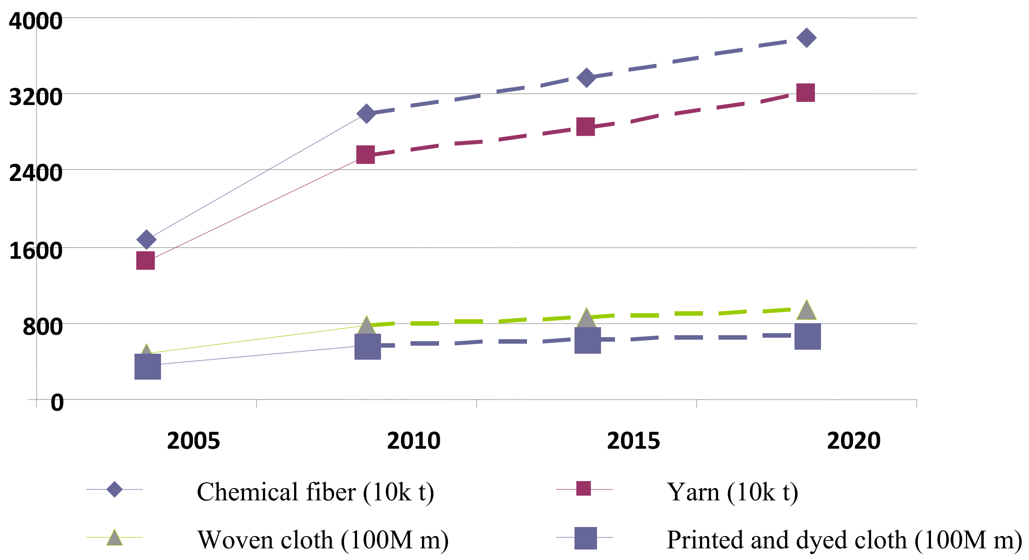
After the reform in managerial systems of industrial sectors, relevant government organs mainly relied on industry associations to organize and coordinate scientific and technological programs. And when local governments, regional governments and other investment entities are all on aboard, diversified parties have participated in program management, causing inconsistence. For making out and implementing energy-saving programs in non-ferrous metal industry, industry associations should lead in organizing, coordinating and mobilizing, so they following the principles of overall planning, overall arrangement, joint implementation can help the researches of key technologies in the industry yield more breakthroughs , and it can even help the whole industry share the breakthroughs. Besides, China should give industry associations more power in surveying, auditing, supervising and assessing the performance of energy-saving in non-ferrous metal industry.

4.6 Textile Industry

4.6.1 Current Status and Development Trend of Textile Industry

Textile industry not only serves as a traditional pillar industry of China’s national economy but also enjoys remarkable competitive advantage in the global economy. During the Eleventh Five Year Plan period, despite the impacts of the global financial crisis, this industry has maintained double-digit growth. In 2010, China’s outputs of such major textile products as chemical fiber, yarn, woven cloth and printed and dyed cloth reached 30.90 million tons, 27.17 million tons, 80 billion meters and 57 billion meters respectively. China is the world’s No.1 producer and exporter of textile products.

Figure 4-18: Growth Trend of China’s Outputs of Major Textile Products between 2005 and 2020



China's textile products enjoy not only remarkable demand in the domestic market but also competitive edge in the global market. In the next decade, the textile industry will continue to enjoy great potential for future growth. During the Twelfth Five Year Plan period, this industry will accelerate its industrial innovation and restructuring. By 2020, China's outputs of chemical fiber, yarn, woven cloth and printed and dyed cloth are expected to reach 97.42 million tons, 79.20 million tons, 203.4 billion meters and 136.2 billion meters respectively.

4.6.2 Development Paths and Potential Contributions to Low-Carbon Development of Textile Industry

(1) Progress in Low-Carbon Development of Textile Industry during the Eleventh Five Year Plan Period

The energy consumption of the textile industry accounts for about 3.6% of China's national total. During the Eleventh Five Year Plan period, the textile industry has adopted various measures in energy conservation and low-carbon development and has made remarkable progress and achievements. This industry has substantially enhanced its independent innovative capability; developed and applied a series of technologies with proprietary intellectual property rights; further optimized its industrial structure; substantially upgraded the overall level of its technical equipment; effectively limited and eliminated its backward industrial capability featuring high energy consumption, pollution and emission; and substantially reduced its energy consumption per unit added value and the energy consumption per unit product of its major textile products. In 2010, China's overall energy consumption per unit product of yarn, woven cloth, printed and dyed cloth, viscose fiber and polyester has decreased by 7.5% to 42% over their levels in 2005.

(2) Development Paths to Low-Carbon Development of Textile Industry by 2020

The major development paths to low-carbon development of China's textile industry will include measures to accelerate the elimination of its backward industrial capacity, promote its progress in energy conservation technologies, further adjust its industrial structure, actively develop cycling economy and improve its corporate energy management.

i) Elimination of Backward Industrial Capacity

Measures to accelerate the elimination of its backward industrial capacity will be an important means for the textile industry to transform it development pattern, adjust its industrial structure, enhance the quality and efficiency of its growth and accelerate its low-carbon transition. Despite the positive progress in the elimination of the backward industrial capacity of the entire industry, the backward industrial capacity of the chemical fiber sector, the cotton textile sector and the printed and dyed textile sector still account for about 10%, 10% and 20% of their total industrial capacity. During the Twelfth Five Year Plan period, this industry is expected to basically achieve the elimination of its backward industrial capacity.

ii) Promotion of Progress in Energy Conservation Technologies

To promote its progress in energy conservation technologies in various fields, the textile industry will adopt measures to optimize its process sequence from the perspective of ecological design to streamline its production links and processes so as to achieve the systematic energy conservation of the entire industry; develop common and key energy conservation technologies to establish an innovation system of energy conservation technologies with enterprises as its major players; organize the development, promotion and application of energy conservation and alternative technologies of such energy carriers as raw material and water; introduce advanced foreign energy conservation technologies; and promote and apply advanced and mature new technologies, processes and equipment for energy conservation.

iii) Further Adjustment of Industrial Structure

Measures to further adjust its industrial structure will be another important means for the textile industry to accelerate its low-carbon transition. This industry will utilize information technology to improve and upgrade its industrial level; adopt strict industrial access standards to restrict the expansion of its backward industrial capability; adjust the industrial structure of its various sectors and their product mix to phase out its low grade products and increase the proportion of its high value added products; and accelerate its response to market demand to shorten its product design cycle and accelerate its product updating and upgrading.

iv) Acceleration of the Development of Cycling Economy

Measures to accelerate the development of cycling economy will be an important new means for the textile industry to achieve its low-carbon development. This industry will follow the principle of “giving priority to reduction” to strive for the systematic reduction of its resource depletion, waste generation and CO_2 emission from the starting point of its production process and for the comprehensive utilization of various resources. The textile industry will adopt measures to develop technologies to use renewable fiber and partially replace chemical fiber with renewable fiber as raw materials; develop and apply technologies to recycle used clothes, to separate the chemical fiber and natural fiber in blended products and to use the separated natural fiber in pulp production; and develop technologies to remanufacture and reuse textile equipment and devices.

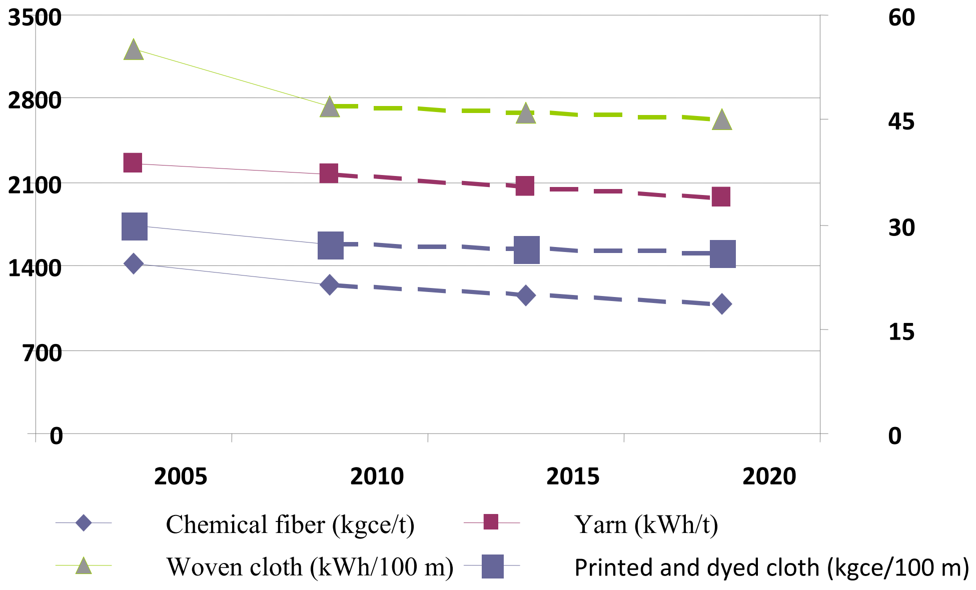
v) Improvement of Corporate Energy Management

Textile enterprises will accelerate the development of their energy management centers and utilize information technology to improve and upgrade the level of their energy management. These enterprises will incorporate Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Computer-Aided Process Planning (CAPP) and Energy Resource Planning (ERP) into the manufacturing of textile machinery to shorten their design cycle and enhance their material utilization; apply computer control technology and advanced Radio Frequency Identification (RFID) technology to the processing, inspection and transportation of cotton; apply centralized management and Distributed Control System (DCS) to the production of chemical fiber; apply automatic air-conditioning monitoring system and ERP automatic cotton blending system to the production of textile products; apply comprehensive inspection and control information system, automatic energy supply monitoring system and video monitoring system to the production of printed and dyed products; and apply Enersys intelligent power management system to power supply. All these measures will play an important role to facilitate the efforts of textile enterprises to upgrade the level of their corporate energy management and reduce their CO_2 emission.

(3) Potential Contributions to Low-Carbon Development of Textile Industry by 2020

In the next decade, the textile industry will embark on the above paths to promote its progress in energy efficiency and emission reduction and is expected to achieve remarkable progress in the conservation of energy and resources and make important contributions to the reduction of CO2 emission. By 2020, this industry will achieve remarkable reduction in the overall energy consumption per unit product of such major textile products as chemical fiber, yarn, woven cloth and printed and dyed cloth and is expected to enhance its capability of annual energy conservation and, in turn, its capacity of annual CO2 emission reduction by more than 35 million tce and more than 80 million t-CO2.

Figure 4-19: Downward Trend of Overall Energy Consumption of China's Major Textile Products between 2005 and 2020



Source: LCIS Task Force analysis

(4). Analysis of the Potential Application of Low-Carbon Technology of Textile Industry by 2020

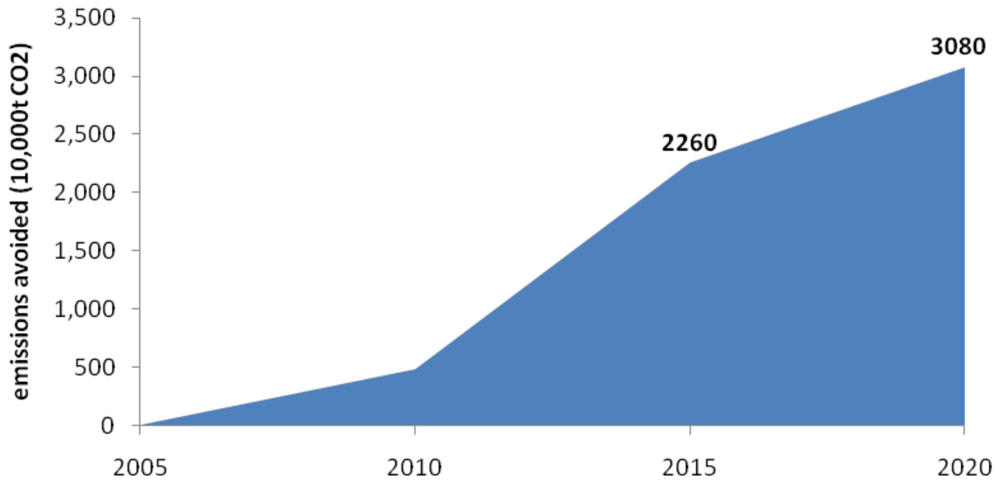
The promotion and application of energy conservation and low carbon technologies are expected to make important contributions to the low-carbon transition of China's textile industry. The five major energy conservation and low-carbon technologies available to this industry include energy conservation technology for the intelligent air-conditioning systems of cotton textile enterprises, energy conservation technology based on the heat gathering of dying and finishing enterprises, dying technology based on high-temperature and high-pressure air stream, refrigerating technology based on the residual heat from the etherification process of polyester chemical fiber and heat transfer technology based on the heat recovery for waster water. The analysis of the above five technologies demonstrates that the application of these technologies in a timely manner and up to their expected proportions is expected to enable this industry to enhance its capability of annual energy conservation and, in turn, its capacity of annual CO_2 emission reduction by about 13.34 million tce and 31 million t-CO_2 by 2020 over their levels in 2005.

4.6.3 Policies and measures

- **Massive Efforts to Promote Energy Conservation through Technical Progress and Industrial Restructuring of Textile Industry**

Efforts should be made to formulate the plans of energy conservation and emission reduction for the textile industry; encourage its application of high and new technologies, advanced appropriate technologies and information technology; study and formulate the standards on the energy efficiency of its energy-using products and equipment and on the upper limit of its energy consumption per unit product and further eliminate its backward industrial capacity and improve its market exit mechanisms accordingly; optimize its industrial distribution, upgrade its industrial access standards, and promote the optimization and upgrading of its organizational structure, product mix and energy consumption structure; and implement the assessment and inspection mechanisms of energy conservation and environmental protection for its fixed assets investment projects.

Figure 4-20: Potential CO_2 Emission Reduction through Promotion of Five Major Energy Conservation and Low-Carbon Technologies of Textile Industry between 2006 and 2020



Source: LCIS Task Force analysis

- **Guidance in and Promotion of Improvement of Corporate Energy Management of Textile Enterprises**

To improve the energy conservation management of key energy-using textile enterprises, efforts should be made to urge these enterprises to establish and improve their energy management systems, develop their energy management mechanisms, prepare their standard energy measurement devices, arrange their energy management posts, employ their qualified energy management personnel and establish their energy conservation responsibility systems; and guide and promote their standard comparison activities for energy efficiency and low-carbon standards and identify a series of benchmark enterprises in energy efficiency and low-carbon development. To strengthen the energy conservation management of small and medium sized textile enterprises, efforts should be made to explore new modes of energy supply in their cluster areas and industrial parks; and encourage energy conservation service providers to provide these enterprises with energy conservation services through energy performance contracting, leasing of energy conservation equipment and financing guarantee for energy conservation projects.

- **Establishment and Improvement of Supervision Mechanisms for Energy Efficiency and Emission Reduction of Textile Enterprises**

Efforts should be made to further implement the responsibility systems for energy conservation objectives of textile enterprises; improve the statistics, monitoring, assessment and evaluation mechanisms for their energy conservation performance; and strengthen the monitoring and inspection of the status of energy utilization and the progress in the elimination of backward industrial capability of key energy-using textile enterprises and disclose information on textile enterprises unable to effectively fulfill their energy efficiency and emission reduction targets.

- **Full Play of the Roles of Industrial Associations of Textile Industry**

The industrial associations of the textile industry play an important role to facilitate the energy conservation efforts of the entire industry. Efforts should be made to bring into full play the roles of these industrial associations as a bridge, a link and a supporter by utilizing and facilitating these industrial associations in the basic management of energy efficiency and emission reduction of the entire industry and facilitating their efforts to upgrade their capability in energy efficiency and emission reduction services.

- **Facilitation of the Establishment of Public Service Platforms for Energy Efficiency and Emission Reduction of Textile Industry**

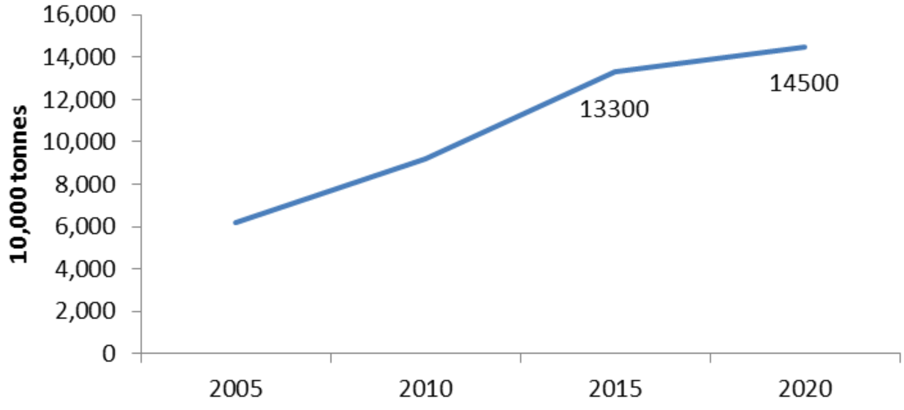
Efforts should be made to facilitate the establishment of the public service platforms for energy efficiency and emission reduction of the textile industry and establish the disclosure mechanisms for information on energy efficiency and emission reduction; and utilize the public service platforms for energy efficiency and emission reduction to provide timely release on energy efficiency status, new technologies, processes and equipment for energy efficiency and emission reduction and advanced management experience at home and abroad, guide textile enterprises to explore their potentials and achieve their upgrades to improve their energy efficiency and reduce their CO2 emission.

4.7 Papermaking industry

4.7.1 Current situation and development tendency of papermaking industry

China is the largest papermaker in the world, with about 3,700 paper and paperboard production enterprises. During the 11th Five-year Plan, although greatly impacted by the global financial crisis, papermaking industry maintained rapid growth. In 2010, the total output of paper and paperboard reached 92 million tons. Compared to developed countries, currently the average paper consumption per head of China remains very low and there is large room for the development of papermaking industry in the future. It is expected by 2020, China's total output of paper and paperboard will reach 145 million tons.

Figure 4-21: Projected paper and paperboard production 2005-2020



Source: LCIS Task Force analysis

4.7.2 Approaches for the low-carbon development of papermaking industry as well as potential contributions

(1) Progress of low-carbon development in papermaking industry during the 11th Five-year Plan

China's papermaking is traditionally a high energy-consumption industry; the energy consumption structure mainly consists of coal, accounting for about 73% in total energy consumption, the second is electricity (about 23%) and others include natural gas, heavy oil and steam. During the 11th Five-year Plan, papermaking industry took many measures in energy saving and low-carbon development, including: new construction, renovation and expansion papermaking projects generally adopted advanced pulping and papermaking technologies and equipment; eliminated a big batch of backward papermaking processes and equipment; in particular, wood pulp production line, waste paper processing and production line and papermaking machine all became large scale, the gap of pulping papermaking technology and equipment was narrowed the global advanced level and proportion of advanced papermaking capacity improved to 70% or so. In 2010, the comprehensive energy consumption of paper and paperboard per unit product declined by about 20% compared to 2005.

(2) Approaches for the low-carbon development of papermaking industry in 2020

In the future, main approaches for energy conservation and low-carbon development of China's papermaking industry will include: accelerate to eliminate backward capacity; improve industrial concentration; further optimize materials structure; develop and promote energy-saving and low-carbon technology, process and equipment; strengthen enterprise energy management.

i) Accelerate to eliminate backward capacity

Currently, backward capacity remains a large proportion in papermaking industry, including small pulping production and small papermaking production with low energy efficiency and high emissions. To accelerate to eliminate backward papermaking capacity will be a practical effective approach for the industry to speed up low-carbon transformation.

ii) Improve industrial concentration

By 2010, China had about 3,700 papermaking enterprises with certain scale, including more than 88% of small and medium-sized enterprises and only 9 papermaking enterprises with a capacity over 1 million tons/year. Generally speaking, small papermaking enterprises have low business level, backward technical equipment and low energy use efficiency. To improve industrial concentration and accelerate large-scale and intensification development in ways such as elimination of backward capacity and enterprise reshuffle, will be important approaches for the low-carbon development of papermaking industry.

iii) Further optimize materials structure

China is a big papermaker and paper-user. China's papermaking industry will make the forestry-paper integration as its main development direction, strive to improve the proportion of wood fiber materials and reduce the proportion of non-wooden fiber papermaking. In addition, the waste paper recovery and use rate will be improved gradually. To further optimize materials structure will also be an important approach for papermaking industry to reduce energy consumption and carbon dioxide emissions in the future.

iv) Develop and promote energy-saving and low-carbon technology

Papermaking is a technology intensive industry; to develop and promote energy saving and low carbon technology, process and equipment is important approach for the low carbon development of the industry. In the future, following technologies and processes will be promoted in the link of pulping papermaking in the industry: extended delignification process in continuous cooking, high-yield pulping technology, biological technology, low-pollution pulping technology, oxygen delignification/ elemental chlorine-free or total chlorine-free bleaching technology, closed screening technology, efficient waste paper deinking technology, water closed cycle technology, efficient waste water treatment and solid waste recovery processing technology, and computer control technology for heat recovery technology, pulping papermaking technical process and management system; paper machines will adopt new dehydration components, wide area squeezing, all closed cover and heat pump. In addition, the thermo-electro combined production technique will be promoted in the industry.

v) Strengthen enterprise energy management

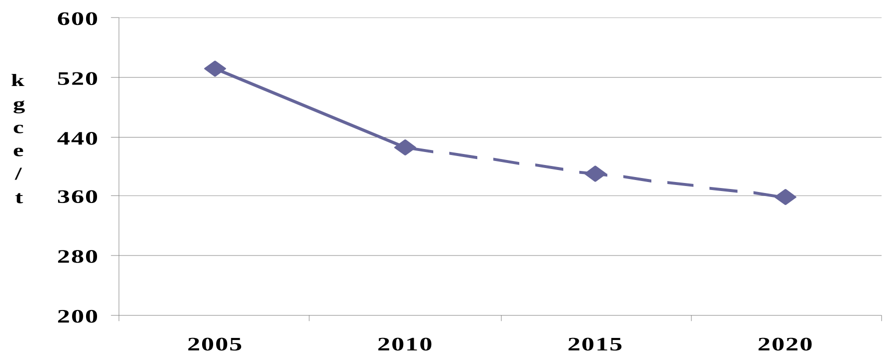
To strengthen papermaking enterprises' energy management and improve energy management level is also important approach for the low carbon development of papermaking industry in the future. Energy saving and low carbon benchmark activities will be conducted in papermaking industry in the future; through pilot projects, establish a batch of energy saving and emissions reduction benchmark enterprises within the industry to promote and improve the overall level of energy efficiency and low carbon development in the industry.

(3) Potential contributions of papermaking industry to low carbon development

In the next 10 years, papermaking industry will promote energy saving and emissions reductions through above approaches. It is expected significant energy resource can be saved and great contributions made to dioxide emission reduction. By

2020, it is expected paper and paperboard energy consumption per unit product will decline by about 33%[94] compared to 2005, an annual saving capacity of 25 million tce will be formed and a corresponding annual dioxide reduction capacity of 58 million tce formed.

Figure 4-22: Potential energy intensity improvement in paper and paperboard per unit product

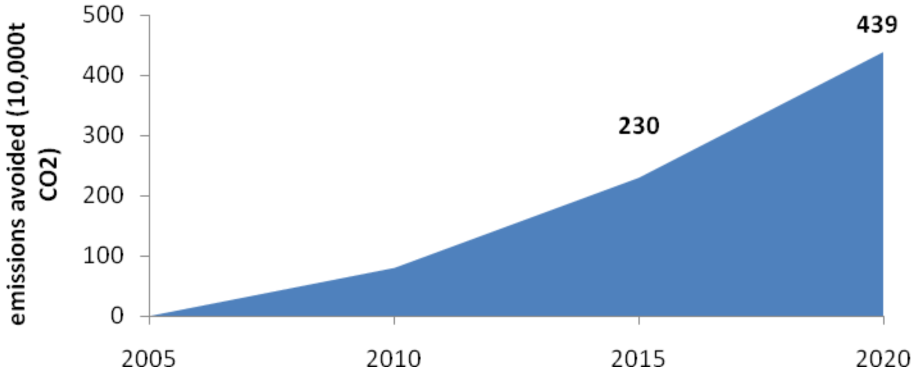


Source: LCIS Task Force analysis

(4) Analysis of promotion and application potential of low carbon technology in papermaking industry in 2020

In the low carbon transformation of China's papermaking industry, the promotion and application of energy saving and low carbon technology is expected to make great contributions. Currently, 4 major energy-saving and low-carbon technologies are available in papermaking industry: energy saving and application technology for turbine vacuum system, papermaking energy system analysis and scheduling information system, efficient double disc pulp grinding technology and pulping papermaking energy system diagnosis and optimization technology. Analysis results of the four technologies show: if these technologies can be timely promoted as anticipated, compared to 2005, these technologies can form an annual energy saving capacity of about 13.34 million tce and a corresponding annual emissions reduction capacity of 31 million t-CO2 in 2020.

Figure 4-23: CO2 emission reduction potential of the promotion of 4 major papermaking energy saving and low carbon technologies (2006-2020)



Source: LCIS Task Force analysis

4.7.3 Policies and measures

1) Establish and perfect energy saving and emissions reduction laws and regulation in papermaking industry

Establish and perfect energy saving and emissions reduction laws and regulation in papermaking industry and in particular, accelerate to develop and revise industrial energy consumption and water consumption standards.

2) Strengthen economic incentive policies for energy saving and emissions reduction in papermaking industry

Relevant proposals include: improve the support of financial and tax policies for the promotion of major energy saving and low carbon technologies in papermaking industry.

3) Encourage and support energy saving and low carbon technology innovation in papermaking industry

Encourage papermaking industry to build a platform for energy saving and low carbon technology innovation where technologies are jointly developed and results shared. Support to construct a batch of energy saving and low carbon engineering centers in papermaking industry to provide technical support for energy saving and low carbon development in the industry.

4) Guide and encourage intensive development of papermaking industry

Relevant government departments shall guide and encourage papermaking enterprises to develop in the direction of scale and intensive operation, and through approaches such as closing, stopping, merge, transferring ,reshuffle and integration, eliminate small papermaking enterprises with low energy efficiency and high emission to create development space for papermaking enterprises with high energy efficiency and good business performance.

5) Intensify energy saving and emissions reduction supervision mechanism for papermaking enterprises

Further intensify responsibility system for papermaking enterprises' energy saving and emissions reduction targets; improve statistics, monitoring and evaluation system for papermaking enterprises' energy saving and emissions reduction; strengthen monitoring and inspection of key energy-use papermaking enterprises' energy utilization and performance of energy saving and emissions reduction responsibilities.

6) Urge and guide papermaking industries to strengthen energy management

Urge papermaking enterprises to establish and perfect energy management system. Guide and promote key energy-use papermaking enterprises to carry out energy efficiency and low carbon benchmark activities and set up a batch of energy efficiency and low carbon benchmark enterprises. Strengthen small and middle papermaking enterprises' energy saving management.

5 THE ROLE OF THE EMERGING STRATEGIC INDUSTRIES

The issue of how to realize the low carbon Industrialization by developing strategic new industry will be discussed in this chapter. The current situation, contribution in emission reduction, and the policies and measures required in strategic new industries like energy saving and environmental protection, low carbon energy, low carbon energy automobile, biological industry, the new generation of information technology, new materials and high-end equipment manufacturing industry will be presented.

5.1 Energy-saving and environmental-protection

Energy-saving and environmental-protecting industry includes technological development, commercial distribution, resource utilization, information service, project contracting and other activities aiming at saving energy, preventing and treating pollution and protecting the ecology. This sector covers energy-saving, resource recycling, environmental protection and relevant technologies, equipment, products and service.

In the 11th Five-Year Plan period, the development of energy-saving and environmental-protecting industry is speeding up remarkably, with its average annual growth rate exceeding 20%. According to incomplete statistics from some industrial associations, until 2009, the whole industry scale amounts to about RMB 1.9 trillion, among which energy-saving industry takes up 18.4% with its RMB 350 billion scale, environmental-protecting industry 28.9%, worth RMB 550 billion, resource utilization industry 53.6% and totaling at RMB 1,000 billion. With an expanding industrial scale, explosive development of concerning technologies and popularization of environmental-friendly products and technologies, this industry is keeping a good development momentum and is forcefully enhancing the process of low-carbon Industrialization.

Table 5-1: Output Value of Energy-saving and Environmental-protecting Industry in Recent Years

	2008		2009	
	Value(Billion RMB)	Proportion (%)	Value (Billion RMB)	Proportion (%)
Energy-saving Industry	270	19.1	350	18.4
Wherein: Service Related	41.7	3.0	58	3.1
Environmental-protecting Industry	480	34.0	550	28.9
Resource Utilization Industry	660	46.8	1000	52.6
Wherein: Recycling and Reprocessing of Waste Resource and Material[95]	1158	8.2	145.3	7.6
Output Value of the Whole Industry	**1,410**	**100.0**	**1,900**	**100.0**

GDP□Billion RMB	34,050.7	39,798.3
Proportion of Energy-saving and Environmental-protecting Industry%	**4.1**	**4.8**

Sources: China Statistical Yearbook, China Energy Conservation Association, China Environmental Protection Industry Association, Chinese Renewable Energy Industries Association and China Environment Service Industry Association.

5.1.1 Prospect on energy-saving and environmental-protecting industry in China

1) Huge market demand

Industrial waste material has experienced a continuous and fast increase in the past five years, with its average annual growth rate as high as 13%. However, the comprehensive re-utilization rate remains low, with the 2010 index being just around 70%[96]. The recycling of used products booms, but recycled non-ferrous metal only comprises 24.3% of the total production of 10 kinds of non-ferrous metal[97]. The 2010 urban sewage treatment rate increased to 75.25%, but there are still 61 cities having no sewage treatment plant, and virtually no sewage treatment facilities exist in rural areas. Landfill remains to be the major way of garbage non-polluting disposal, with the proportion of burn and compost being less than 20%, much lower than that of Japan and South Korea[98]. In the end of 2010, energy consumption per unit of GDP dropped to 1.042 tons of standard coal per RMB 10,000, still lagging behind developed countries[99]. In the 11th Five-Year Plan period, the central budge earmarked over RMB 200 billion in energy conservation and pollution reduction. The total social investment in this cause amounted to about RMB 2 trillion, about 2% of the social investment in the same period[100]. Considering China's present energy efficiency and environmental management ability, the investment in this area will be furthered expanded to fulfill its long-term strategic goals. Even calculated by the present 2.5% growth rate, the investment in the next 10 years is estimated to reach RMB 5.4 trillion.

2) New technologies to promote energy-saving and environmental-protection

Modern technology is becoming the commanding height of competition in energy-saving and environmental-protection. China already possesses a set of mature traditional technologies and equipment, initially established R&D system and generic platforms, as well as some key industrialized technologies and generic technologies, including energy-saving technologies like TRT, gas turbine using low caloric value gas, pure cryogenic residual heat power generation and pure cryogenic residual heat power generation; environmental-protecting technologies including power generation by grate furnace incineration of waste and dried sludge. Some technologies and equipment are internationally competitive, such as surface treatment technologies in remanufacturing, automatic production line for recovering waste circuit boards, thermosetting plastics of electronic waste recycling, refrigerants recycling technologies and equipments and so on.

5.1.2 Energy-conservation and environmental-protecting industry & low-carbon Industrialization

Industry is the major energy-consuming sector in China, whose terminal energy consumption accounts for 70% of the total[101]. At present, Chinese enterprises still lags behind advanced foreign counterparts in terms of major products energy consumption (see Table 5-2). Developing energy-saving and environmental-protecting industry is highly relevant to transforming traditional sectors to low-carbon model in the sense that it could reduce per unit energy consumption, promote resource re-utilization and cut cost. There are three ways to realize this transition: first, directly reducing energy consumption in the production process by adapting energy-saving technologies, products, equipments and management; second, reducing resource consumption and its impact on ecological environment by developing circular economy and improving energy efficiency; third, developing energy-saving and environmental-friendly products and services with less resources and raw material.

Table 5-2: Energy Consumption of Major Industrial Products

	China			International Advanced Level	Gap (2005)		Gap (2009)	
	2005	2008	2009		Energy consumption	Proportion (%)	Energy consumption	Proportion (%)
Thermal power supply coal consumption (gce/kWh)	370	345	339	312	58	18.6	27	8.7
Steel comparable energy consumption for large and medium enterprises (kWh/t)	714	663	644	610	104	17.0	34	5.6
Electrolytic aluminum, AC consumption (kWh/t)	14680	14323	14131	14100	580	4.1	31	0.2
Copper smelting, total energy consumption (kgce/t)	780	564	548	500	280	56.0	48	9.6
Cement, total power consumption (kgce/t)	167	151	139	118	49	41.5	21	17.6
Crude oil refinery, total energy consumption (kgce/t)	114	106	106	73	41	56.2	33	45.3
Ethylene, total energy consumption (kgce/t)	1073	970	954	629	444	70.6	325	51.7
Synthesis ammonia, total energy consumption	1650	1549	1521	1000	650	65.0	521	52.1

(kgce/t)								
Caustic soda, total energy consumption (kgce/t)	1297	1154	1075	910	387	42.5	165	18.1
Soda ash, total energy consumption (kgce/t)	396	345	306	310	86	27.7	-4	-1.2
Paper and paperboard, total energy consumption (kgce/t)	1380	1158	--	640	740	115.6	518	80.9

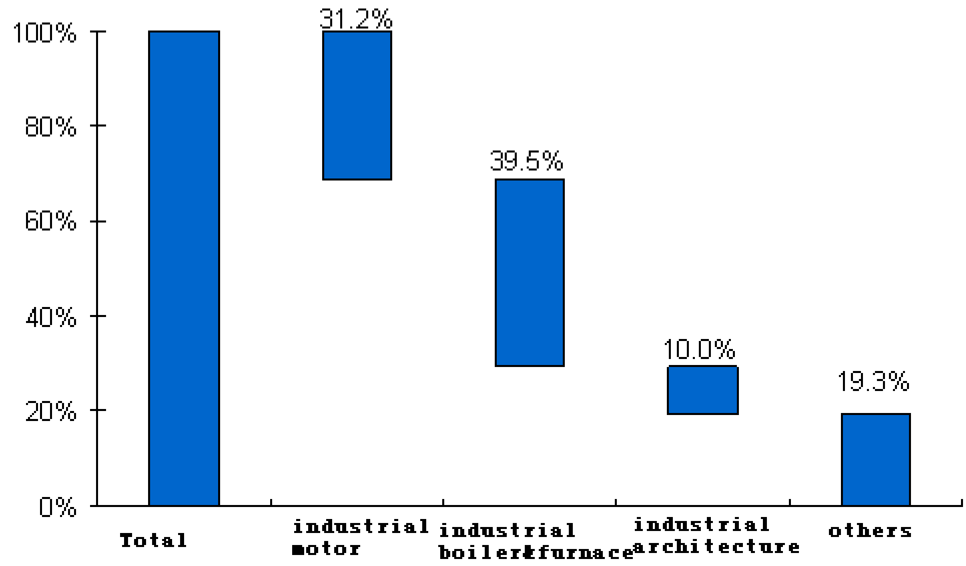
Notes: See endnote # 102

Source: State Statistics Bureau, Ministry of Industry and Information Technology, China Electricity Council, China Iron and Steel Association, China Building Materials Industries Association, China Association for Chemical Energy Saving Technologies, Handbook of Energy & Economic Statistics in Japan (2010) by the Institute of Energy Economics, Japan, Journal of the Japan Institute of Energy, Iron & Steel Institute Japan and Korea Iron & Steel Association.

1. Reduce energy consumption in industrial production

In China, the energy consumption in the process of industrial production happens most often in the fields of industrial power distribution, industrial motor, industrial boiler and furnace, and industrial building (including air-conditioner and lighting), etc. (See Figure 5-1). In terms of links, the energy consumption in the process of industrial production has the following problems: I. the capacity and specification of the electric transformer and distribution line are not matched with their actual load, which leads to the low efficiency of the power supply and distribution system. II. The equipment configuration is unreasonable. The electricity consumption in industrial motor system (including electric motor, water pump, fan and compressor) takes up about 80% of the total electricity consumption in China, while the market occupancy of the high-efficiency energy-saving motors even does not reach 3% and the operational efficiency of the electric motor system is generally 20%[103] or so lower than that in developed countries. III. The actual operational efficiency of industrial boiler (furnace) is comparatively low, ranging from 15% to 20% lower than the average level of developed countries. As one of the most important thermal power equipments in industrial production in China, the industrial boiler (furnace) consumes more than 20% coals in China. IV. The energy consumption of industrial construction is still not brought to forefront. Compared with civil architecture, industrial architecture has much larger room and its energy-saving reconstruction requires more investment but receives less prominent effect. So it is difficult to inspire the initiative of enterprises to take action of energy-saving reconstruction. At present the energy consumption of industrial architecture is about 10% of the industrial energy consumption in China and the energy-saving architecture takes up substantially small share.[104]

Figure 5-1: Distribution of Energy Consumption in Process Of Industrial Production



Source: Calculated and Arranged according to Data from "Energy Statistical Yearbook in 2009 China"

The low-carbon industrialized process is boosted through developing energy-saving environmental-protection industries and extensively promoting energy-saving products, equipments, technologies and management methods in the process of industrial production. The detailed measures are as follows:

i. **Enhance the management of energy consumption at the industrial terminal, especially the side management on electric demand side and energy saving management to reduce the energy waste and equipment loss.** Choose suitable transformer or other power transforming equipment. Systematically manage quality of electric power of the power distribution rooms located in different factories or on different floors to realize the goals of both clean power and energy saving and effectively protect the load equipment at the end.

ii. **Develop high-efficiency energy-saving terminal load equipment such as boilers and furnaces, motors, dragging equipment and waste heat and pressure utilization equipment, and energy-saving monitoring equipment.** In 2011, the sale of high-efficiency electrical motors is expected to get to 30% of the whole electrical motor sale and it will rise year by year in future. By means of abandoning old electrical motors and greatly increasing sale proportion of high-efficiency electrical motors (annually increasing by 5-10% on average), the popularizing rate of high-efficiency electrical motors is estimated to reach 80% by 2020. Considering it saves 15% energy, the electricity consumption of high-efficiency electrical motor will be reduced by 750 billion KWH, which is equal to decrease of carbon dioxide emission by 568 million tons. In China, the annual energy consumption of industrial boiler and furnace reaches over 700 million tons and the actual operational efficiency is 15-20%

lower that the overseas advanced level. If the operational efficiency of 70% industrial boilers and furnaces is improved to the level as high as the present advanced level, it is expected that energy consumption and carbon dioxide emission will be reduced by 210 Mtce and 437 million tons respectively , compared with the situation before reconstruction and upgrading.

iii. **Make the existing industrial architecture under energy-saving reconstruction to and develop low carbon energy-saving industrial architecture.** It comprises optimizing architecture design of factory buildings, fixing outer surrounding structure, and popularizing high-efficiency lighting devices and energy-saving air-conditioners and fans, which are aimed at reducing energy consumption of industrial architecture. Now the issue that industrial construction should be environmental-friendly has not been taken seriously yet. There are a few pilot projects in Shenyang, etc. If around 20% of existing industrial architectures go through the energy-saving reconstruction by 2020 and the energy consumption per building area drops by 15%, the energy consumption will decrease by 14.9 Mtce and emission of carbon dioxide will reduce by 345 million tons.

iv. **Boost energy saving service industry, build integrated service platform and provide package services of energy saving diagnose, design, financing, reconstruction and operation for energy consumption companies.** According to rough estimation, there were about 800 energy saving service enterprises in 2010 China with revenue of around 85 billion RMB, which saved 10.7 Mtce energy in way of offering energy saving service. At the speed of up 23% annually, the revenue of energy saving service industry is forecasted to reach 600 billion RMB by 2020, 40% of the total revenue of the energy-saving industry. The industrial departments will see 98.8 Mtce down in energy consumption and 115 million ton down in carbon dioxide emission through adopting energy saving service.

2. Develop cyclic economy and promote recycling of resources

It does not only polish recycling facilities and technologies of wastes and wasted industrial products, but also construct and complete related recycling service system so as to improve the usage efficiency of renewable resources to boost resource recycling industry. Specifically speaking, the correlation between energy-saving environmental-protection industry and low-carbon Industrialization process in the field of resource recycling and comprehensive utilization is reflected as follows:

i. **Accelerate the spreading of essential technologies and facilities of resource recycling.** That is, accelerate the recycling of tailings, smelting residues of major non-ferrous metal and wasted products through providing new technologies and facilities for separation, enrichment and comprehensive utilization of minerals and high-efficiency clean disassembling technology and facilities of industrial products for wasted machinery, electrical appliance and plastics.

ii. **Promote the application of renewable resource to the production and everyday life.** It comprises utilizing solid wastes such as desulfurized gypsum, fly ash, coal gangues and smelting residues to produce new building materials; increasing utilization ratio of renewable metal, renewable rubber and renewable plastic; making machinery products such as wasted car into reproduced products such as car parts, engineering machinery, machine tool, communication and transportation equipment, drilling equipment and military equipment. The carbon emission of the industrial department will be sharply cut down. For example, the energy consumption of one ton secondary copper consumes only 27%of the energy that one ton primary copper does. In 2010, the recycling rate of 10 non-ferrous metals was 26.6% of the annual yield. Wherein renewable aluminum contributed about 30% and renewable copper took up about 59%, which considerably fell behind advanced industrial countries. The utilization ratio of wasted steel is comparatively low. In 2010 the total amount of recycled wasted steel was about 15% of the annual yield of crude steel. Considering the current development speed and existing distance between China and advanced countries, the utilization ratio of renewable aluminum, renewable copper and wasted steel is expected to reach 65%, 75% and 25% respectively by 2020; the energy consumption and carbon dioxide emission will be reduced significantly.

iii. **Develop service industry for resource recycling and enrich the existing service system of cyclic economy.** On one hand, taking cyclic enterprises and distribution market as carriers, integrate, transform, standardize and upgrade existing recovery system to build community recovery stops; standardize recovery company and recovery system in close combination with distribution market. On the other hand, construct service platform including research and development of remanufacturing engineering technology, safety detection of reproduced products, and quality identifying of remanufactured products through establishing waste recovery system and using message switching network to further culture and complete service system engaged in research and development, consulting service and application of cyclic economy technology.

3. Provide high-efficiency energy-saving and material-saving products and services

The low-carbon development of industrial department is not only reflected in efficiency of industrial production process or recycling, but also finds expression in the capacity of developing a large number energy-saving, material-saving and environmental-protection products, such as household and commercial electrical appliance, lighting products, building materials and vehicles. Therefore, the energy and raw material that is necessary for industrial production itself will be reduced and the energy consumption of the whole society will be indirectly cut down. It is an inseparable part for low-carbon Industrialization that industrial departments develop low-carbon consumption or terminal products. It can be achieved in following ways to develop energy-saving environmental protection industry and promote development and demonstration of high-efficiency energy-saving environmental-protection products:

i. **Develop and popularize high-efficiency energy-saving environmental-protection household appliances.** It includes developing high-efficiency energy-saving air-conditioners and refrigerator compressor, DC inverter compressor, DC inverter controller, reinforced heat transfer technology of gas water heater, solar water heater and varied intelligent control energy-saving equipments; promoting high-efficiency energy-saving products including air-conditioner, refrigerator, washing machine, electric cooker, water heater and electric warmer. According to 2009 Resource Statistical Yearbook, the electricity consumption of household appliance is about 13.5% of the total in China. As the popularization of household appliances in China, especially in rural China, the proportion of electricity consumed by household appliances will be rising. Now the sale of energy-saving household appliances is about 15%-30% of the whole sale; as respect to some household appliance, the percentage even surpasses 50%; the energy-saving household appliance is estimated less than 10% of the total inventory of household appliances. During the coming ten years, the inventory of household appliance will annually rise by 5% or so in China and the proportion of energy-saving household appliance will rise to around 40%. Given each piece of household appliance saves 30% electricity power, 67 billion KWH will be saved by means of energy-saving household appliance in China by 2020, in equivalence to carbon dioxide emission reduction by 50 million tons.

ii. **Develop and promote high-efficiency energy-saving commercial or public products.** It includes developing high-efficiency heat exchanger technology, energy storing device, refrigerating and freezing technology, flow and pressurization technologies of centrifugal impeller, and low-energy consumption mainboard, memory and power technologies; promoting unitary air-conditioner, multi-connected air-conditioner, chillier unit and external power adaptor; popularizing high-efficiency energy-saving office supplies such as duplicator, printer and fax machine. The electricity consumption of the office buildings, all kinds of venues, warehouses and other public buildings is 55% of the household electricity consumption, for the public buildings are relatively concentrated so that the energy-saving campaign is more easily carried out and the government at all levels attach great importance to energy saving in public buildings. By 2020 the carbon emission will be reduced by 27.9 million tons through adopting high-efficiency energy-saving products.

iii. **Develop and promote high-efficiency energy-saving lighting products.** It includes developing vital device and core materials of semi-conductor lighting such as gallium chloride material, OLED material and device; developing general crucial technology for semiconductor lighting Industrialization such as high-power chip and device, drive control and standardized module system integration; developing light source products such as ballasted lamp for ordinary illumination, metal halide lamp and high pressure sodium lamp, and relevant ballast. According to preliminary estimation, the electricity consumption of lighting is 10-12% of the total. About 1.4 billion incandescent lamps are in use in China now. During the three years from 2008 to 2010, nearly 350 million energy saving lamps were accumulatively promoted with the help of financial subsidies. If 150 million lamps are annually popularized in the future, it will take 7-8 years to replace all the ordinary incandescent lamps with energy-saving lamps. According to the conservative estimation that each lamp saves 50 KWH, 70 billion KWH will be saved through using energy saving lamps by 2020 in China and carbon dioxide emission will be reduced by 53.1 million tons.

iv. **Develop energy-saving and new-energy vehicles.** Develop technical equipment with proprietary intellectual property right including new storage battery for vehicle and new electromechanical coupling power system of hybrid power vehicle, power system for vehicle and generating equipment. Demonstrate and promote pure electric vehicle and hybrid power vehicle; explore and use traditional energy-saving technology of vehicles with high fuel economy. Annually 109 million tons gasoline will be saved through developing energy-saving environmental-protection vehicles by 2020 and carbon dioxide emission will be reduced by about 300 million tons.[105]

v. **Develop energy-saving building material products and upgrade heat supply means.** It includes developing new wall materials such as new thermal insulation wall material, reinforced flyash brick, gangue sintered brick and reinforced bearing blocks, energy-saving construction windows and doors and water-proof insulation system for walls. According to different heat supply and cold supply means, corresponding solution is provided to improve the whole energy efficiency of building. By 2020 carbon dioxide emission will be reduced by 113 million tons through energy saving reconstruction of building, adopting energy building materials and increasing heat supply efficiency.

Table 5-3: Specific Contribution of Energy-saving Environmental-protection Industries to Low-carbon Industrialization

Main links	2015		2020	
	Energy saving	Emission reduction	Energy saving	Emission reduction
	10,000 tce	10,000 tons of CO2	10,000 tce	10,000 tons of CO2
Reduce energy consumption in the process of industrial production				
Wherein: high-efficiency electric motor	6400	14720	24700	56810
high-efficiency boiler (furnace)	8990	20677	20570	47311
energy-saving industrial building	500	1150	1500	3450
energy-saving service	2250	5175	5000	11500
Develop recycling economy				
Wherein: recycling of wasted steel	6018	13842	8764	20157
develop and promote energy-saving and environmental protection products				
Wherein: energy-saving household appliance	1422	3271	2164	4977
energy-saving public commercial products and office supplies	813	1869	1212	2788
energy-saving lighting	1815	4175	2310	5313
energy-saving environmental-protection vehicle	5950	13684	13043	30000
energy-saving building material	2300	5290	4900	11270
Subtotal of Contribution	41529	95516	96422	221772

Note: see Section 3 of this figure for calculation details of contribution of energy-saving and environment-friendly vehicles to low carbon Industrialization.

5.1.3 Main Bottlenecks in Developing Energy-Saving& Environmental Protection Industry in Promoting Low Carbon Industrialization

1) Weak Technological Basis for Innovation

The numbers of most energy-saving and environmental protection equipments that are made in China are in a rise, such as frequency converters, highly efficient lighting equipments, dust collectors, desulfurizing devices and sewage disposal facilities. Moreover, some products like dust collectors and energy-saving home appliances are even exported to other countries. However, China are now still in bad need of crucial and generic green technologies with independent intellectual property rights. Key technologies, equipments and materials rely heavily on imports. While there are many manufacturers in China, companies engaged in R&D and services remain scarce. Added value of products and services is low, for instance, China is the largest manufacturer of lighting devices in the world, but its products are mainly low- or medium end, which cannot give the industry chain a huge pull.

2) Imbalance in Industrial Structure

Among all manufacturers of environmental protection equipments, less than 5 percent are large companies, whereas the fixed assets of 85% companies are no more than 15 million RMB. Only 5 companies can handle 10,000 tons of wastes per day to generate power, concentration ratio of the industry are lower than 8%. In 2010, there are more than 800 companies in the industry, but its development is sporadic or sprawling where most companies can only offer a single technology in their energy-saving services. Compared with the overall solution programs provided by large international corporations, these companies are apparent underdogs.

3) Sluggish structural reforms and supporting policies

First, some local governments and relevant departments are only focused on developing and introducing companies that would yield time-saving benefits, as a result, there will be inadequate attentions and investments in energy-saving and environmental protection industry. Normally, much money are put in initiating new projects, it will be strapped when it comes to structural researches and capacity improvements. There are needs, but there is not market. Second, external costs are not only made up of energy and environment costs. Relevant taxes and fees are low and hard to levy. At present, it costs only RMB 0.8 or even less to treat each ton of sewage. If the plants deal with the sludge as well, the cost will rise up to RMB 1.2 per ton. The problem is even trickier in handling city trash. In cities that take charges in handling its waste, usually there are only 30% to 50% of their residents paying for it. Third, preferential and encouraging measures have their deficiency, i.e. the incentives are not enough. For instance, environmental protection enterprises, like other enterprises, are subject to 25% of income tax. Measures to offset the taxable income at a certain ratio of the investment amount or accelerated depreciation are rarely implemented. The supports of preferential policies to these companies are insufficient.

4) Lack of private investment

Compared with developed countries, China's capital market and environmental exchange market are immature: money raised directly from capital markets is not much; the financing of energy-saving and environmental protection companies or service facilities are largely dependent on franchise and banks. However, initial investments in this area, especially service area, are high, the proceeds are relatively low, the cycle is long and relevant financing guarantee system is yet to improve. So far, the banks do not totally approve of taking the franchise as collateral, it's very hard for some companies to loan. Even worse, the business model of energy-saving and environmental protection companies is mostly one-fold, their cash flow can easily be interrupted, therefore, their developments are always confronted with great capital shortages.

5.1.4 Policies and Measures to Promote Development of Energy-Saving and Environmental Protection Industry and to Accelerate Low Carbon Industrialization

1) Short and Medium Term Development Plan for the Industry and Strengthen Policy Coordination

In accordance with the aims and tasks of the 12th five-year plan to save energy, reduce emission, control pollution and develop green industry, relevant departments should promulgate as soon as possible the *Short and Medium Term Development Plan for Energy-Saving and Environmental Protection Industry*, make clear of developing ideas, main objectives and corresponding policies and measures. The conformity of current policies and the coordination among departments in charge should be strengthened; plans at all levels should be in convergence and support each other to unite as one. The governments should also promptly issue policies to facilitate the R&D of environmental protection technology, Industrialization and trade, to accelerate independent innovation and technology introduction, to foster a number of leading companies with core competitiveness, and to accomplish fast development in the industry.

2) Resource pricing and market incentives

First, a resource products price formation mechanism, which can flexibly reflect demands and needs, scarcity of resources and environment costs, should be established and improved. China will put forward water price reform to charge differential fees according to different usage of the water. Effort will be made to set up a pricing mechanism for refined oil, which links the market with the price. The price peg between natural gas and alternative energy needs to be made clear. The resources tax will be moderately raised and levied in a better way, so to promote more proper use of resources.

Second, China needs to produce more energy-efficient products, equipments and buildings, introduce strict limitations to protect the environment. China should accelerate our efforts in formulating energy labels and implementing energy-efficient standards for key products, improve energy audit system, and carry out more restrictions on the discharge of industrial/domestic waste water and on the emission of air pollutant from coal power plants, industries and automobile exhaust. China should also perfect supervision networks for energy-saving, enhance constant online monitoring and control of environment, set up an assessment platform for clean technology as well as a service platform for the development of recycling economy.

Third, the governments should impose environment tax and a higher fine to polluting activities, intensify fee collection efforts for the treatment of waste water and domestic garbage, and severely punish those who violates the regulations. In order to deal with wastes like family appliances, electronics and automobiles, China should gradually implement the system of extended manufacturers' responsibility.

3) Introduce a Strategy to Promote the Application of Energy-Saving and Environmental-Protection Technology and improve technical levels

China will ask helps from all relevant parties as soon as possible to formulate a systematic strategy to promote the application of energy saving, environmental protection technology, set up a mechanism to guarantee that the technology be accepted in the market. First, governments are supposed to play the role as a guide, so to increase the independence of enterprises in their R&D and application. They should also encourage these companies—especially private ones—to take part in major national projects, support the establishment of a technology innovation system with enterprises as its center, facilitate the transfer and Industrialization of outstanding green projects. Second, China will optimize the verification platform and product testing platform of energy-saving projects, improve the standardized system for energy-saving and environmental protection technology, and implement a supervision system for green technological projects and equipments. Third, China will establish a special institution to promote transactions of green technologies, such as energy-saving, environment-friendly equipments and services, so to eliminate structural, capital or informational obstacles in the transaction. Fourth, China will regulate the transaction market of green technologies. A sound market environment will facilitate R&D and application of technologies, equipments and products. China will also promote the proper distribution of green technologies among small companies and large corporations, and ultimately put forward the development of the industry.

4) Increase Financial Input And Improve A Diversified System For Investment And Financing

The investment and operation of the green industry need a lot of money. On one hand, governments can increase input through direct investment, establishment of a fund for the operation of green facilities and bond release at both national and local level. Supposing that the environment tax is levied, some of the revenue can be used to save energy and reduce emission. On the other hand, the industry should embrace foreign and private investment to enlarge the multiplier effect of fiscal capital and make better use of capital market. China will raise as much money as possible.

5) Preferential taxes and support

More companies in the industry will be given a tax preference, and the preferential policy should be tilt from green equipment manufacturing to green service enterprises. For the research and development enterprises, the tax preference should focused on support when the technologies are in the preliminary stage, such as fee deduction and tax concession, while the preference will tilt to the encouragement in the later stage of the research, such as levy lighter or even no tax. For companies who offer operation services to green facilities, the governments should levy lighter turnover tax, income tax and land use tax, and introduce investment deduction and accelerated depreciation at the same time.

5.2 Low carbon energy

5.2.1 Global development trend of low carbon industry

1) Acceleration of Innovation

Innovation in low carbon energy technology is gaining momentum, energy efficiency ratio was raised remarkably and the price goes down dramatically. The maximum capacity of an individual wind turbine rose from 30 kilowatt in 1980s to 5000 kilowatt at present, the price for surfing the internet down from 15.8 euro cents per kilowatt hour to 4. The power generation efficiency of silicon-based solar photovoltaic goes up from less than 10% in 1990s to 17%-18% at present. 82% of technological learning curve emerged, which means that if the scale doubles, the price will fall by 18%. The price of wind power is likely to go down to 3 euro cent per kilowatt hour, and the price of solar power will equal the price of thermal power around 2020.

2) Low carbon energy industry is undergoing large-scale and rapid development

Low carbon energy industry, which is undergoing large-scale and rapid development, accounts for a large amount of low carbon energy supply. The once supplement energy now becomes a major substitute energy. During the past decade, photovoltaic solar power increased by 38% annually, and wind power increased by 28% annually, wind power capacity installed in Europe accounts for more than 50% of the total capacity installed.

3) Major Countries Pay Great Attention to the Development of Low carbon energy

The development of low carbon energy was considered as a strategic pivot for the solution of financial crisis and climate crisis; therefore, major countries in the world put more money in relevant areas. After the international financial crisis, the US and EU as well as other major countries take the low carbon energy industry as an emerging business and start to transform towards low-carbon economy. In their economic stimulus packages and regular research budgets, investments in low carbon energy were increased. 10% of the stimulus package of the US, i.e. 80 billion dollars, was for the development the low carbon energy, which is the record investment in the energy areas in American history. The European Union also intensified their support for the research and development of the low carbon energy, for instance, the EU planned to spend up to 1.25 billion euro on just a pilot project of carbon capture and sequestration technology.

5.2.2 China's low carbon energy resources and industry development

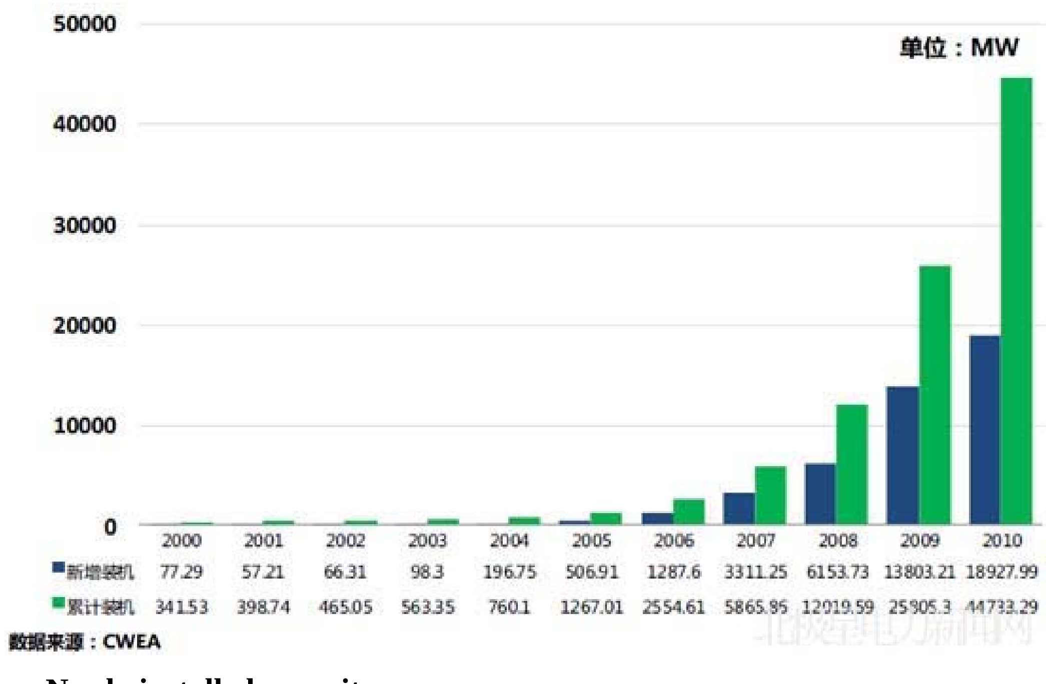
1) Abundant renewable resources in China

The technically developable installed capacity of hydropower is 540 million kilowatts, with an annual power generation capacity of 2.47 trillion kwh, ranking No.1 in the world. With 2/3 of the total territory enjoying over 2,200 hours of annual sunshine hours, there is abundant solar resources to be tapped. The annual solar radiation is higher than 5,000 MJ per square meter, equivalent to 170 kilograms of standard coal per square meter. There is 300 million kilowatts of usable wind power on land, coupled with offshore wind resources available, making up a total of about 1 billion kilowatts of wind power. The current potential of biomass converted power is equivalent to 500 million tons of standard coal. With the efforts of forestation and economic and social progress, the potential is expected to grow up to 1 billion tons of standard coal.

2) Rapid progress made in the development and utilization of low carbon energy

In recent years, wind power and other renewable energy have developed rapidly in China. By the end of 2010, hydropower reached 213.4 million kilowatts. The installed capacity of nuclear power exceeded the 10 million kilowatts mark and reached 10.82 million kilowatts. There are 26 units of nuclear powered generators under construction with an additional capacity of 29.14 million kilowatts. The total integrated grid capacity of wind power reached 31.07 million kilowatts. (The installed capacity of wind power with completely erected turbine is 44.73 million kilowatts, see Figure 5-2). The proportion of installed capacity of non-fossil power accounted for 26.5% of the total, 1.1 percentage points higher than in 2009. The accumulative power generated by non-fossil resources was 786.2 billion kwh, equivalent to 263 million tons of standard coal by coal-fired power conversion, accounting for 8.11% of the country's total energy consumption. In 2010, solar water heater covered 168 million square meters of floor area, while solar collectors covered a total of 40 million households with 150 million people. Wind power capacity added by 18.928 million kilowatts, accounting for half of the newly installed wind power capacity globally. On-grid wind power tariff dropped to 0.5 ~ 0.6 RMB / kwh. The solar power price went down even faster than expected. In 2008, the officially approved on-grid solar power was 4 RMB / kWh. In March 2009, the average biding price in the Gansu Dunhuang solar power project was down to 1.5 RMB / kwh, and the bid-winning price was 1.09 RMB / kWh. In the latest solar power project bidding, the winning bid price was 0.72 RMB / kwh.

Figure 5-2: Newly installed and aggregated installed capacity of wind power in China



Blue - Newly installed capacity

Green - Aggregated installed capacity

Source: CWEA

3) Rapid expansion of low carbon energy industry

Localization and large-scale manufacture of nuclear power equipment has made progress, reaching a production capacity of 6 - 8 sets of equipment annually. Wind power equipment manufacturing capacity also grew significantly; the products from domestic manufactures and joint ventures accounted for 90% of newly installed capacity (see Table 5-4 below). In 2010, the annual production capacity of PV cell components reached 15GW, and the output was 8GW, a y-o-y increase by one fold, accounting for more than 50% of the global share. The polycrystalline silicon production totalled 40,000 tons or so, meeting 50% of domestic demand, with an additional 6 million-ton production capacity under construction. The annual added coverage of solar water heaters reached 46 million square meters, accounting for more than half of global output.

Table 5-4: Top 20 manufactures of newly installed wind power capacity in 2010

No.	Manufacturer	Installed capacity(MW)	Market share
1	Sinovel	4386	23.2%
2	Gold Wind	3735	19.7%
3	East Turbine	2623.5	13.9%
4	United Power	1643	8.7%
5	Ming Yang	1050	5.5%
6	Vestas	892.1	4.7%
7	Shanghai Electric	597.85	3.2%
8	Gamesa	595.55	3.1%
9	XEMC Windpower	507	2.7%
10	China Creative Wind Energy	486	2.6%
11	CSIC (Chongqing) Haizhuang Windpower	383.15	2.0%
12	CSR Times	334.95	1.8%
13	Envision Energy	250.5	1.3%
14	GE	210	1.1%
15	Suzlon	199.85	1.1%
16	Hua Yi	161.64	0.9%
17	Yin Xing	154	0.8%
18	Windey	129	0.7%
19	SANY Electric	106	0.6%
20	Changxing Wind Power	100	0.5%
Others		**382.9**	**2.0%**
Total		**18927.99**	**100%**

Data source: CWEA

5.2.3 Development goals for the low carbon energy industry and the estimated contribution to energy conservation and emission reduction

1) Development goals

Low carbon energy development goals: China's non-fossil energy accounted for 8.1% of the total energy consumption in 2010. According to the "Twelfth Five-Year" plan, by 2015, the proportion of non-fossil energy will reach 11.4% of the total energy consumption. The proportion will further increase to 15% by 2020, with an installed capacity of 150 million kilowatts of wind power; 80 million kilowatts of nuclear power, and 20 million kilowatts of solar power, as suggested by the National Climate Change Program.

Low carbon energy industrial development goals: First, the industry scale. The current annual output of China's low carbon energy equipment industry is RMB 200 billion, of which photovoltaic cells industry accounted for RMB 70 billion; and the industries of solar, wind and nuclear power contributed RMB 40 billion each. The goal is to increase the annual industrial output by one fold to over RMB 400 billion by the end of the "Twelfth Five-Year" plan. Considering the driving effects to the design, installation, operation, maintenance, and supporting industries, the low carbon energy industry is expected to bring about trillions of GDP growth every year, constituting a staunch force of economic growth. Second, improve industrial innovation capacity and competitiveness. During the "Twelfth Five-Year" plan period, China should manage to achieve independent and localized equipment manufacturing, especially for the key components, and make breakthroughs in the assimilation of the third generations of nuclear power technology, high-power wind generation, solar polycrystalline silicon manufacturing and other key technologies. By 2020, the low carbon energy industry is expected to establish enhanced R&D capacity, and command advanced nuclear power, offshore wind power and the third-generation solar technologies. The industrial competitiveness should be refocused from low labor cost to high technical components and economies of scale, making the industry one of the advantageous sectors of the national economy.

2) Contribution to energy conservation and emissions reduction

Based on the above mentioned plans, the carbon dioxide emission reduction through application of non-fossil energy is estimated as follows (see Table 5-5): By 2015, low carbon energy resources will replace 467 million tons of standard coal, equivalent to 1.15 billion tons of carbon dioxide emission reduction, 500 million tons more than 2010, reducing per unit GDP emission by 3 percentage points. By 2020, i.e. during the “Thirteenth Five-Year Plan” period, the replacement volume will reach 720 million tons, equivalent to 1.771 billion tons of emission reduction, 620 million tons more than 2015, further reducing per unit GDP emission by 3-4 percentage points.

Table 5-5: Forecast on non-fossil energy development and evaluation on CO_2 emission reduction

	2010	2015	2020
Total energy consumption (100 million tce)	32.4	41	48
The proportion of non-fossil energy	8.11%	11.40%	15%
Hydropower installed capacity (10,000	21340	28000	43000

kilowatts)			
Wind power installed capacity (10,000 kilowatts)	3107	9000	15000
Nuclear power installed capacity (10,000 kilowatts)	1082	4000	8000
Solar power installed capacity (10,000 kilowatts)	60	500	2000
Alternative energy (100 million tce)	2.63	4.67	7.20
CO2 emission reduction (100 million tce)	6.46	11.50	17.71

5.2.4 Problems existed in low carbon energy industry development

1) Inadequate technology base

First, China has not commanded core technologies of the industry, and the key components are still dependent on imports. China's wind power capacity has increased dramatically, but R&D on new generator models is halting at introduction and assimilation of advanced imported ones. The control system and key bearings of wind generation equipment are still relying on imports. China have a big solar cell industry; but China have not yet controlled the preparation and purification technology of polycrystalline silicon, and the recovery technology of toxic by-product such as silicon tetrachloride, which are difficult to develop or introduce. The nuclear power generation, construction and operation capacity has seen significant improvement, but the overall design remains as duplication of imported models; the design principles and know-how are still to be learned. There is still a long way to go in the localization and independent manufacture of large forgings, main pumps and special materials. Second, the supporting system for technological innovation is inadequate. Research institutions are scattered, mostly in various universities, lacking a consolidated platform for the development and commercialization of common technologies. In addition, the industry is full of small enterprises with limited R&D capability, while large equipment suppliers like General Electric, Westinghouse, Mitsubishi and Siemens are hard to find. Even for large enterprise with certain economic scale, their R&D capabilities may not as good as that of small- and medium-sized expertise companies in developed countries.

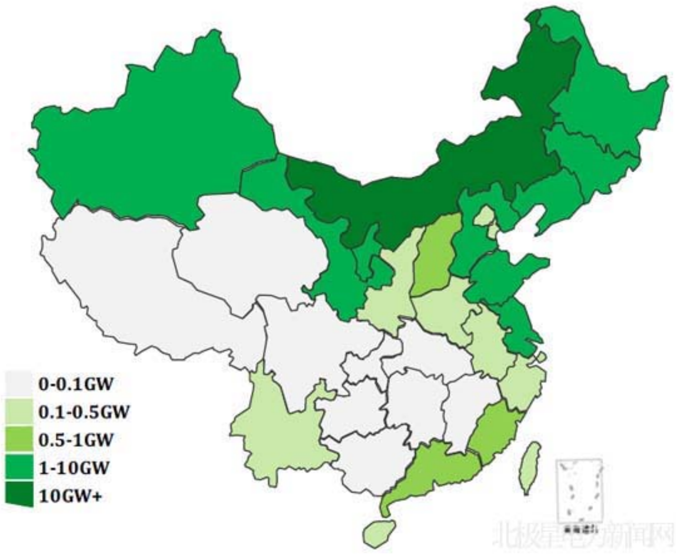
2) Discipline and regulations required

Currently, in the sub-sectors of wind power and photovoltaic power equipment manufacturing, there are few technical standards; the mandatory testing and accreditation regime is yet to be established; and the industrial technical threshold is lacking. That has brought two problems: First, enterprises rushed into the industry, causing cutting-throat competition. Due to policy incentives and lack of entrance threshold, the industry is inundated with new comers. There are over 70 wind power generator manufactures, the largest four of which have a total capacity of over 12 million kilowatts. There are more than 30 polycrystalline silicon manufacturers. While lacking core technology and innovation capacity, those companies entered into price competition, or even vicious competition, at the expense of product quality and consistency. Second, the product quality is compromised. Due to the "explosive" growth of the industry, many products have only had a very short cycle from R&D to mass production, so potential problems may not be fully exposed or effectively resolved. Therefore, huge volumes of products went on the market before sufficient testing, which may lead to large scale of equipment failure and significant losses.

3) Misalignment of low carbon energy concentration areas and load centres

The natural distribution of low carbon energy resources is rather random, and the power generated from those resources fluctuates. The generated electricity has to be re-allocated in a large geographic area, in order to buffer power fluctuation on the grid. China's low carbon energy resources, especially wind, usually locate far away from the load centres (see Figure 5-3), and requires large-scale power transmission. However, there are still bottlenecks, resulting in high proportion of wind power in some areas, such as Jilin. In certain hours, power generated from wind accounts for 25% of the total load, which is detrimental to the safe operation of power grid, and restrains further development of wind power.

Figure 5-3: Aggregated installed capacity across various provinces in 2010



4) Structural problems have resulted in idle capacity

The wind power industry, for instance, has an installed capacity (with completely erected turbine) of 44.73 million kilowatts by the end of 2010, but the integration grid capacity is only 31.07 million kilowatts. The huge idle capacity of wind power industry is partially attributed to temporary factors, such as the comparatively slower pace of grid construction than power generation. However, the fundamental cause lies in the industrial structure, including lack of coordination between low carbon energy development and power grid construction, delayed transfer of the rising costs of power generation, and lack of mandatory requirements and supervision on power grid companies.

5.2.5 Thinking on the development of low carbon energy industry

The development of China's low carbon energy industry can be summarized as following: innovation-driven, rooted in local conditions, equal access and two-way motivation.

1) Innovation-driven

The speed and scale of low carbon energy development must be integrated with the development of low carbon energy equipment manufacturing industry and particularly the improvement of technical innovation capacity. At the same time of using financial and tax policies to develop low carbon energy markets, pay more attention to low carbon energy industry and significantly improve R&D, design, manufacturing and operation capacities through demand pull, break technical bottleneck, develop an emerging industry with technical innovation as core capacity and add new engine for economic growth.

2) Rooted in local conditions

Internationally, most European countries have taken a path of distributed utilization. In Germany, the majority of wind power with a total installed capacity of 23 million KW is medium and small wind fields, the installed capacity of the biggest wind power is only 60,000 KW and most wind power is directly connected to the distribution network and digested in local areas. The US not only develops large wind power but encourages the development of distributed energy such small wind power and family solar energy. China shall take the path of combination of large-scaled development and distributed development. China will not put attention only to large wind power, large nuclear power, large photo electricity and large power grid. Specifically, in terms of power generation, not only build wind power and photo electricity bases in regions with rich resources and collectively use low carbon energy on a large scale, but encourage the construction of medium and small wind fields and utilization of small wind power in regions with general conditions and accelerate dispersed utilization of solar power on a wide area. In terms of power utilization, adopt the guideline of "long-range power transmission and local utilization", not only accelerate to construct power transmission channels to transmit power of low carbon energy bases to load centers, but encourage to develop energy-carrying industries with relatively low stability requirement and small water consumption near renewable power sources to transfer energy in form of energy-carrying products; at the same time, improve power grid intellectualization, gradually realize the two-way power supply of distributed energy utilization system and improve digestion capacity in local areas.

3) Equal access

Currently, it's urgent to establish reasonable access policies, technical standards and market mechanism, especially when current power supply and demand are temporarily surplus, further promote power system reform, improve supervision of equal access to power grid and ensure investors to use power grid facilities without discrimination.

4) Two-way motivation

Use price, finance and tax policies to actively encourage social investments, but the subsidy policy for low carbon energy price must play roles in two aspects: first, improve the economy efficiency of low carbon energy through price subsidy to accelerate and expand the utilization to realize scale economy of the industry; second, form efficiency motivation for investors and promote their cost reduction and technical innovation. Since the implementation of wind power proprietary right bid, despite of problems such as cutthroat competition, the introduction of competition mechanism has significantly reduced wind power feed-in tariffs. Wind power benchmark price, which is set according to region resources, can avoid cutthroat competition, but abandon the function of finding price by market. As technical progress is accelerated currently, it is hard for the government to set prices scientifically and reasonably, form efficiency motivation for investors, promote technical innovation, improve efficiency and reduce cost. The low carbon energy development must not be maintained by the government's long-term subsidy. The current moderate subsidy is to make low carbon energy competitive in economy and the price subsidy needs to be focused on the long-term objective.

5.2.6 Policy measures to accelerate the development of low carbon energy industry

1) Establish and publish planning for low carbon energy development

The State Council has published the Decision on Speeding up the Cultivation and Development of Strategic Emerging Industries. The 12th Five-year Overall Plan has been approved by the National People's Congress and entered implementation period. The industry and the social public have a high expectation for its promulgation and implementation. The planning shall be promulgated as early as possible, making clear goals at all stages, main thought, key tasks and policy measures.

2) Accelerating innovation

Public R&D agencies and test platforms are very important in technical innovation system for low carbon energy, and play a crucial role especially in basic and generic technology R&D, Industrialization promotion and implementation of major government research plans. As China's low carbon energy research forces are dispersed and short of specialization and also interdisciplinary integration. It is proposed to establish open national low carbon energy research institutions. National low carbon energy research institutions not only have general scientific research conditions and facilities but pilot scale test ability, the test ability in the whole process from basic research, technical R&D and test demonstration to detection and certification. National low carbon energy research institutions shall be open to enterprises, universities and other research institutions and its function is to engage in basic and genetic technology R&D, test, experiment and certification to address inefficient supply of generic technologies in low carbon energy industry.

Further improve relevant policies to encourage independent innovation. First, stick to and carry out existing effective technology policies. Implement independent relying engineering and promote the independence and domestication of low carbon energy equipment through relying projects. Second, implement Adjustment and Revitalization Plan of Equipment Manufacturing Industry as soon as possible, establish risk compensation mechanism for using the first unit of home-made equipment and encourage insurance companies to develop insurance business for the first unit of major home-made technology equipment. Implement tax preference policy to encourage technical innovation. In addition, innovate scientific research organization forms, guide to set industrial innovation alliance, and support industry alliance to be focused on the domestication of generic technology and key parts with government funds in Industrialization.

3) Standards, certification and inspection system

Implement wind power equipment certification system: first, establish design and certification standards for wind power and solar power whole machines and key parts, which shall be in line with China's natural environment, resources condition and industrial basis; second, accelerate construction of inspection and certification capacity; third, implement unified wind power and solar power certification system and implement compulsory product certification. What's more, establish wind power and photo-electricity synchronization technology standard as soon as possible. The establishment of synchronization technology standard shall be led by the government and jointly participated by parties such power grid companies and power generation equipment manufacturers. The standard establishment shall not only refer to international standards and be some prescient and instructive to lead equipment manufacturers to development friendly power grid technology and ensure power grid safety, but also give consideration to current situation of our industry and reserve some buffering time for domestic manufactures as well as capacity construction.

4) Power grid and coordination of low carbon energy power supply planning

Advance construction of power transmission network, wise distribution network and energy storage facilities step by step. First, accelerate construction of power transmission channels and network routes of low carbon energy projects, and particularly, accelerate to construct access lines for existing low carbon energy projects and address problems of equipment abandonment. Second, advance construction of wise and interactive power distribution network in central cities such as Beijing and Shanghai. Third, accelerate construction of energy storage facilities, pay close attention to development of low carbon energy storage technologies, and encourage to constructing energy storage facilities and loading centers in low carbon energy bases to stabilize power grid fluctuation and support low carbon energy development.

Strengthen unification and coordination of low carbon energy power supply planning and power grid planning. Since plant and network separation, the discordance between plant and network become very obvious and it is very outstanding in low carbon energy field. In order to solve the problem, the first is to definite planning body. National departments in charge of energy are the body responsible for low carbon energy development planning and power network development planning. Relevant planning of network enterprises and local governments shall be in accordance with national overall planning. The second is to improve the planning science and seriousness. An important mechanism to ensure the science is multi-party participation by power source enterprises, power network enterprises and government planning departments.

5. Pricing mechanism and management system and establish institutional environment suitable for the large-scale development of low carbon energy

Electricity price formation mechanism shall be perfected. In order to meet the demand for large scale low carbon energy development, electricity price mechanism shall be further perfected. Currently, the combination between proprietary right bid and benchmark electricity price can be adopted: on the one hand, for large-scaled low carbon energy projects with good resource conditions, continue to implement proprietary right bid and provide reference for the government to set and adjust benchmark electricity price through introduction of competition to reduce cost; on the other hand, for projects with distributed use and bad resource conditions, implement low carbon energy benchmark feed-in tariffs by regions to encourage enterprise investment and regulate the government's pricing behavior. In addition, according to low carbon energy development scale, timely adjust the additional level of renewable energy resources and fully share the cost increase caused by low carbon energy development.

Improve management system. Low carbon energy technology innovation and industry development involve several departments, such as National Energy Administration, Ministry of Science and Technology, Ministry of Industry and Information Technology, National Development and Reform Commission, Ministry of Finance, Ministry of Environmental Protection, Ministry of Housing and Urban-Rural Development and National Standards Commission. In order to strengthen coordination among departments and avoid chaotic management, China shall strengthen organization and coordination among government departments and define roles and responsibilities of each department.

6) Mandatory measures and economic incentives in the power sector

Currently, low carbon energy development is short of the requirement for the key link of power network enterprises and is also short of incentive polices to benefit power network enterprises. So it is proposed to implement renewable energy quota system for power network enterprises, a mandatory provision that the electricity purchased by power network enterprises must have certain proportion of renewable resource. On the other hand, timely adjust the additional level of renewable energy resources, immediately address cost increase caused by low carbon energy development and do not narrow profit space of power network enterprises.

5.3 Energy efficient and electric vehicles

5.3.1 The international trend of efficient automobiles

1) Electrification and diversification

To meet the ever-pressing energy and environmental challenges, a major technological revolution is now underway in the global automobile industry, with energy efficient and alternative energy automobiles. Electric automobiles, after taking into account multiple factors, such as comprehensive assessment of product functions, contribution to environmental protection and energy conservation, energy supply and social ancillary facility building, has obvious superiority over energy-saving automobile and alternative energy fuelled automobile.

Japan leads in the field of Hybrid Electric Vehicle (HEV) and Japanese companies are focusing on the development of HEV first before turning to pure electric cars. The Japanese government has formulated the development plan—The Next Generation of Automobile, intending to increase the number of low carbon energy powered automobile into 13.5 million by 2020. To reach this target, at least 17 models of electric automobile and 38 models of HEV should be developed by 2020.

With substantial and increasing strength in the internal-combustion engine technology, European companies are making step by step preparations for the future development of electric cars, while continuing to maintain their predominance in the internal-combustion engine sector. In October, 2009, the Europe Union released *European roadmap—Electrification of Road Transport*, giving more support to electric automobile and plug-in hybrid electric vehicle. In August, 2009, the German government adopted *National Development Plan for Electric Mobility (NEPE)*, pushing forward at the same time the development of electric vehicles and PHEV, and planning to churn out 1 million electric vehicles and PHEVs by 2020.

The US government pulls their weight behind the development of PHEV, intending to set it as the breakthrough direction in low carbon energy powered automobile, and the acceleration of the transition into the development of electric automobile. The US government plans to devote 2.4 billion dollars for the R&D and Industrialization of PHEV and its key parts, aiming to have 1 million vehicles put in use by 2015.

2) Stimulated by relevant policies, electric vehicles are going through accelerated development.

The United States, Europe and Japan have all increased policy support for alternative energy vehicles, including a major push forward on electric cars. More policy stimulus will be given to customers and the fostering of market for electric automobile expedited. The US has provided tax incentives for PHEVs, reducing tax by $2,500 to $15,000. Japan, from April, 2009, began to give tax preference to electric automobiles and HEVs with the total annual tax reduction around 210 billion yen. And in April, 2009, the UK has adopted new tax policy on the car industry, exempting electric vehicles from excise duty. Financial support such as credit aid was given to automobile manufacturers to accelerate the Industrialization of electric vehicles. Furthermore, the US's new regulations on improving automobile fuel economy and European's rules on average carbon dioxide emission of new vehicles all have posed very strict restrictions on vehicle's oil consumption and carbon dioxide emission. If the manufacturers do not make use of the electric vehicle technology, they can hardly meet these new requirements of law.

Major automobile manufacturers, such as American auto-makers the General Motors and Ford and European giants like BMW and VW, following the steps of Japanese companies, have increased investment in the commercialisation of electric vehicles. Nissan Motors planned to put electric vehicles into the market on a large scale between 2012 and 2013. Mitsubishi, Renault, Toyota BMW and other auto-makers have also developed light electric cars, which posed to enter into market around 2012.

5.3.2 China's improvement in the R&D and Industrialization of low carbon energy powered automobile

1) R&D over the last two five-year plans has positioned China's electric vehicles for emerging global markets

With the support of two major energy conservation and low carbon energy powered automobile projects funded by the state 863 program, the tenth and the eleventh five-year plans, hundreds of domestic car manufacturers, motor or battery producers and other parts makers, universities and research institutions, through organized, big-scale, intense, and non-stop R&D, have acquired core technology of electric vehicles, established a technological platform of electric car driven force system with independent intellectual property rights, formed a supportive R&D mechanism for key parts, and realized the demonstrative operation of small-scale whole-vehicle manufacture and commercialization in some regions. At present, over 160 models of electric vehicles have been listed in the China Auto Products Bulletin, around 30 state-level technological innovation platform was instituted, such as key state laboratories, 42 electric-vehicle-related standards were formulated; all this combined to prove that our electric vehicles have already acquired primary conditions for Industrialization.

2) Electric vehicle is entering a stage of mass deployment

Our electric vehicles were the first to be equipped with high-capacity and efficiency lithium ion battery. And the vehicles' driving force, economical efficiency, endurance mileage and noise indicators all reached the international level, proving that China have acquired primary independent R&D and supportive industrial production capabilities of key technologies. 12-long electric bus's electricity consumption has dropped to kWh per hundred km, and that of A-rated electric cars to 16.5. Electric cars have a top speed of over 120km/h, covering 180 km after one single charge. The independent R&D of HEVs has been focused on key technologies such as idling and start-stop and speeding up and boosting, and brake energy recovery.

3) Chinese batteries are approaching the international advanced level

China have independently developed series of 6-100 ampere-hour nickel-hydrogen and lithium ion powered batteries for vehicles, making obvious improvement in key indicators such as power density and energy density. The power density of lithium ion powered battery has been increased to 2500 watt per kilogram in 2008, up from 491 watt per kilogram in 2002, an increase of over 4 fold. The battery module has a normal recycle expectancy of around 1000 times. The energy density of high-capacity Lithium Iron Phosphate Battery can reach up to 100 watt-hours per kilogram. High-power nickel-hydrogen powered battery for HEVs with an electrical quantity of 85%, if discharge with a rate of 20-30, can reach a 0.1 second peak power of 1173 watts per kilogram.

The investment made by Chinese powered battery enterprises has been strengthened substantially, making them acquire initially the design and production capacities for the basic manufacture facility of powered battery; relatively big battery manufacturers with competitive potential are growing rapidly. According to statistics, the annual production capability of nickel-hydrogen and lithium ion powered batteries for vehicles in the country has exceeded 140 million watts per hour and 900 million watts per hour. The figures were expected to exceed 360 million watts per hour and 4 billion watts per hour respectively by the end of 2010. Suppose that every electric vehicle be equipped with a 30 kWh battery (A-rated car with an endurance mileage of 200 km), over 150,000 electric vehicles can be equipped in 2010.

4) The infrastructure for electric vehicles has undergone initial development and fledgling networks have been formed in some cities

To keep up with demand of the exemplary application of electric vehicles, the domestic energy supply infrastructure for electric vehicles has been developed initially, with the completion of 98 charging stations of various kinds, 325 charging posts, 2 large-sized charging stations for electric buses, 62 charging tower for super capacitor bus lines, 3 hydrogen generation & refueling stations and 3 moving hydrogen refueling stations.

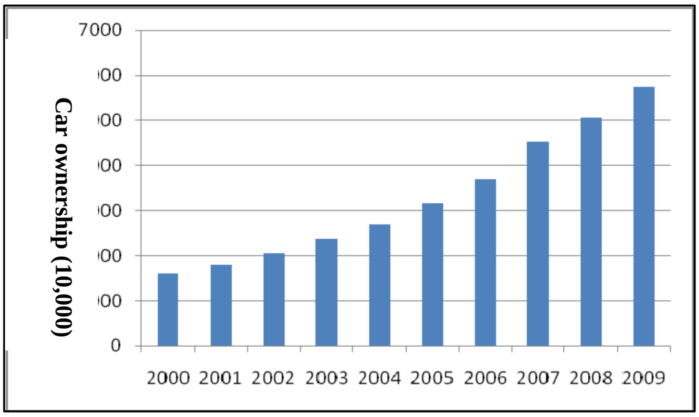
The city of Beijing has increased investment in charging infrastructure to meet the demand that 1,050 electric buses be put into exemplary application by 2010 on the basis of large-sized electric bus charging stations built during the Olympic Games. And the city of Shanghai has combined the exemplary operation of 1,000 energy-conserving and low carbon energy powered buses in 2010, and built one model speed charging station, 147 charging posts, 62 charging towers for super capacitor bus lines and 2 hydrogen refueling stations inside the World Expo Park. The Shenzhen municipality has selected 19 bus stations for the implementation of charging facilities, with 5 of them already completed and in operation. Also, the city of Wuhan has built about 30 electric vehicle charging stations, initially forming an electric bus charging network.

With the implementation of the 2009 program—Thousands of Low carbon energy Powered Vehicles in Ten Cities, the potential opportunities, offered by the infrastructure providing energy supply for electric vehicles, has been paid great attention. The National Grid Company, China Southern Power Grid, Potevio Company and other energy enterprises have took part in the building of electric charging infrastructure around the state's development strategies of low carbon energy powered vehicles; and various exemplary cities and all walks of life responded actively.

5.3.3 The transformation to low-carbon poses new demand on the development of china's energy-conserving and low carbon energy powered vehicles

In recent years, as the people's living standard is improving and the national economy developed rapidly, the number of vehicles owned by Chinese citizens continues to rise at a fast speed. In 2000, the total number of civil automobile stands at 16.09 million; by 2009, the figure has already reached 57.42 million, a threefold increase over eight years, with an annual growth rate of 15.2%, as shown by Figure 5-4. In the decades to come, the number of civil automobiles will continue to grow at a very high speed. As forecasted, the total number of vehicles will reach 153.36 million in 2020 and 240.5 million by 2030.

Figure 5-4: Automobile ownership (from 2000 to 2009)



The rapid increase of automobiles has posed great challenges to China's energy conservation and emission reduction. In terms of energy consumption, the percentage of China's automobile fuel consumption on the overall oil consumption[106] continue to rise, reaching 29.3% in 2008 up from 25.1% in 2005. Based on current oil economy, and suppose that the automobile growth pattern and average annual mileage pattern remain fixed, then by 2020 our automobile oil consumption will reach 333 million ton, and by 2030 over 500 million ton.

In terms of carbon dioxide emission, suppose that the carbon dioxide emission per ton of oil remain the current level (about 3 ton), then by 2020 China's carbon dioxide emission brought by automobile will be four times that of 2005, a growth rate almost the same as that of GDP (suppose that in the course of 15 years the growth rate stay at around 10%). Compare this prospect with the current target that by 2020 the carbon dioxide emission per unit of GDP be 40% to 45% less than that of 2005; we know that energy conservation and emission reduction in the use of automobiles must be done as quickly as possible.

5.3.4 The contribution of energy-conserving and low carbon energy powered automobiles to energy conservation and emission reduction

According to different oil-saving and emission reduction capacity, energy-conserving and low carbon energy powered automobiles are divided into three categories. The first kind of cars, called energy-conserving cars by us, has some advantages over traditional oil-fuelled cars. This includes conventional cars that have adopted oil-saving technologies, conventional cars that have turned to diesel oil, part of the alternative energy fueled cars and low-level HEVs. Oil-saving technologies that can be adopted by conventional automobiles include high-efficiency internal combustion engine technique, driving and propelling technique, car design optimization technique and car light-weight technique. The second kind of cars has relatively better oil-saving capability, mainly HEVs with a mixture ratio of over 40%, including intermediate and high-level HEVs. The third kind of cars, therefore, can run completely without oil-fueled power. This includes electric vehicles and PHEVs. The following is a forecast of the role these kinds of cars will play in energy conservation and emission reduction in 2020 and 2030.

1) Energy-conserving automobile's contribution to the energy conservation and emission reduction

It is forecasted that in the year 2010, conventional cars will still be the mainstream of the automobile market; however, with the development of oil-saving technologies, their oil economy will be improved. In addition, low-level HEVs will become popular. As a result, it is hereby predicted that the first kind of energy-conserving cars will be 88% of the total amount of automobiles by 2020. And their oil-saving rate will increase by over 30% (as compared with that of 2005, the same hereafter), which means that the oil consumption per vehicle will be dropped by 30%. Thus, **the oil-saving ratio brought by the first kind of energy-conserving vehicles will be 88% * 30% = 26.4%.** The ratio for carbon dioxide emission will be slightly lower than 26.4%, because part of these cars, such as biomass fueled vehicles, make virtually no contribution to emission reduction during life cycle, even though they have certain effects of oil-saving. Taking this into consideration, we predicted that **the emission reduction proportion contributed by the first kind of cars will be around 25%.**

By 2030, with the prevalence of middle-level or above HEVs (with a mixture ratio over 40%) and electric vehicles, the market share of the first kind of energy-conserving vehicles will drop a little bit, by around 55% according to estimation. And with the further releasing of oil-saving potential of conventional cars, the oil-saving ratio per vehicle of conventional cars will reach 40%. Thus, **the oil-saving ratio**

brought by the first kind of energy-conserving vehicles in 2030 will be 55% * 40% = 22%. The ratio for carbon dioxide emission will be slightly lower; and **the emission reduction proportion contributed by the first kind of cars in 2030 was predicted to be around 20%.**

2) The forecast on HEVs' contribution to the energy conservation and emission reduction of automobiles

By 2020, middle-level or above HEVs will be receive certain degree of popularity, reaching 9% of the total amount of automobiles according to prediction. The oil-saving ratio of this kind of vehicles against conventional oil-fueled cars will reach around 40% by 2020, thus **the oil-saving rate contributed by HEVs will be 9% * 40% = 3.6%.** As to the aspect of emission reduction, the emission reduction proportion of HEVs per life cycle is equivalent to that of oil-saving proportion, so **the oil-saving ratio contributed by HEVs will also be 3.6%.**

By 2030, middle-level or above HEVs will continue to be popularized, becoming one of the mainstream models in the car market and accounting for 35% of the total amount of automobiles. Meanwhile, the oil-saving and emission reduction capacities of these cars will be further improved, with the oil-saving and emission reduction ratio per vehicle reaching 50%. As a result, **middle-level or above HEVs' contribution proportion to the energy conservation and emission reduction was assessed at 35% * 50% = 17.5%.**

3) The forecast on electric vehicles and PHEVs' contribution to the energy conservation and emission reduction of automobiles

As compared to HEVs, the technologies of electric vehicles and PHEVs is not mature yet, and the breakthroughs of their core technologies still exist some uncertainties, so that it is hereby predicted that by 2020 this kind of vehicles will only account for a small portion of the total amount of automobiles, around 3%. The electric vehicles will be totally powered by electricity, making their oil-saving ratio 100%. PHEVs can also totally rely on electric power during short distance ride inside the urban area, but have to be powered by burning oil while running outside the city or on expressway. So, this kind of vehicles' oil-saving ratio per vehicle will be 90% in the year 2020. As a result, **electric vehicles and PHEVs' contribution proportion to the energy conservation and emission reduction was assessed a**t **3% * 90% = 2.7%**. In terms of emission reduction, considering electricity being secondary energy and coal fired electricity will continue to account for a high percentage, the emission reduction capability of this kind of vehicles is obvious not as strong as their oil-saving capability. By 2020, under the condition that coal fired electricity account for 70% of the electric power and part of them adopt IGCC, the estimated life-cycle carbon dioxide emission brought by the consumption of electricity of electric vehicles will be around 50% of the carbon dioxide emission brought by the consumption of petrol oil by oil-fueled vehicles. Thus, **the life-cycle emission reduction ratio of electric vehicles and PHEVs will be 3% * 90% * 50% = 1.35%.**

By 2030, with the further development and maturing of battery, motor and electric control technologies, electric vehicles and PHEVs will be popularized, estimated to account for 10% of the market. Then, the development of technology will enable PHEVs to get rid of reliance on oil. So the oil-saving ratio will be near 100%. Thus, **these vehicles' contribution proportion to the energy conservation and emission reduction was assessed at 10% * 100% = 10% by 2030.** In the aspect of emission reduction, under the condition that coal fired electricity account for 60% of the electric power, all of them adopt IGCC and part of them adopt CCS , **the life-cycle emission reduction ratio of electric vehicles and PHEVs will be estimated at 10% * 100% * 70% = 7%.**

4) The sum of various vehicles' contribution to the energy conservation and emission reduction

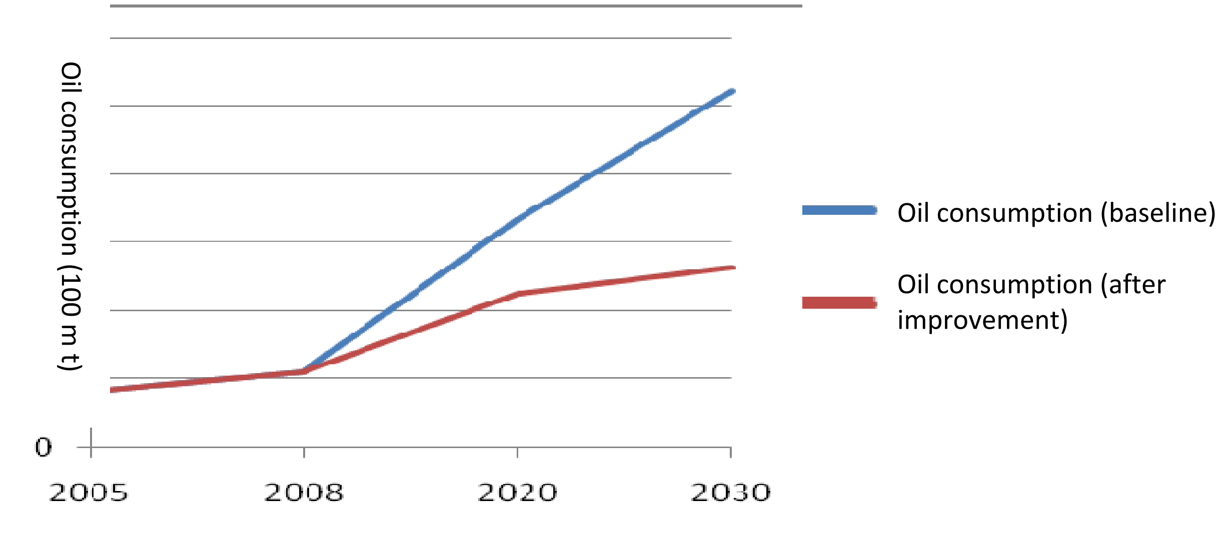
The above forecast numbers have been summarized in Table 5-6

Table 5-6: Emission reduction prediction of energy-conserving and low carbon energy powered automobiles

		2020	2030
Vehicles owned and its percentage	Total amount of vehicles (10,000)	15360	24050
	Conventional vehicles	88%	55%
	HEVs	9%	35%
	Electric vehicles	3%	10%
Oil-saving ratio per vehicle	Conventional vehicles	30%	40%
	HEVs	40%	50%
	Electric vehicles	90%	100%
Sum contribution to oil-saving	Conventional vehicles	26.4%	22%
	HEVs	3.6%	17.5%
	Electric vehicles	2.7%	10%
Sum contribution to emission reduction	Conventional vehicles	25%	20%
	HEVs	3.6%	17.5%
	Electric vehicles	1.35%	7%

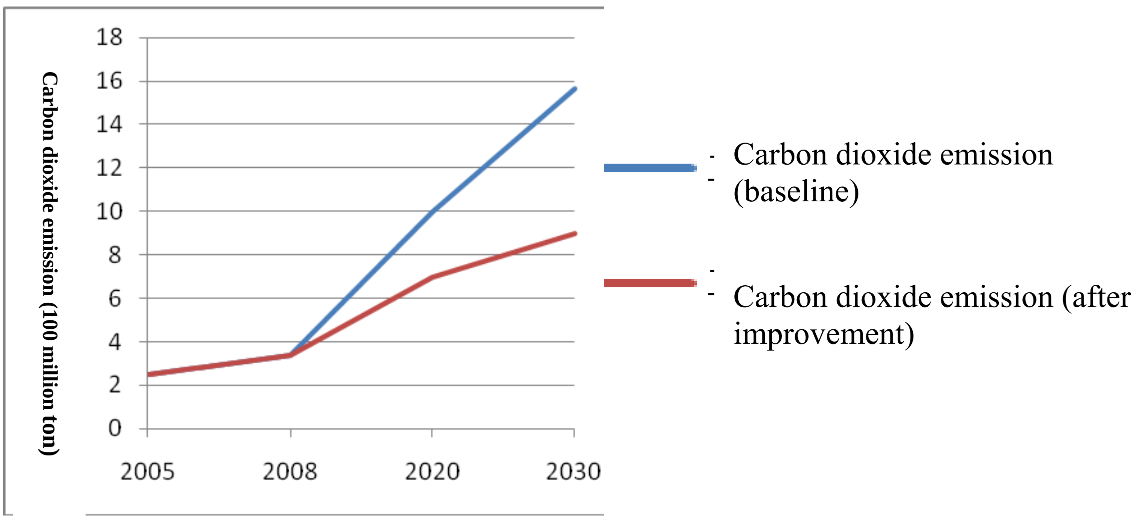
With strengthened development of energy-conserving and low carbon energy powered automobiles, the oil-saving rate of the three kinds of vehicles will therefore reach 32.7% and emission reduction rate 30% in 2020, as compared with 2005. In 2030, the oil-saving rate of these vehicles will reach 49.5% and emission reduction rate 44.5%. That is to say, in 2020, the development of oil-saving technology for conventional automobiles and the popularity of low carbon energy powered vehicles will enable the oil consumption and carbon dioxide emission to be reduced by around 109 million ton and 300 million ton respectively, as compared with the baseline. By 2030, the oil consumption will be less than the baseline by 256 million ton, and carbon dioxide emission will reduce by 666 million ton. Figure 5-5 and Figure 5-6 show the contribution to energy conservation and emission reduction by the development of oil-saving technology for conventional automobiles and the popularity of low carbon energy powered vehicles.

Figure 5-5: Energy-conserving and low carbon energy powered automobiles' contribution to oil-saving



Source: LCIS Task Force analysis

Figure 5-6: Energy-conserving and low carbon energy powered automobiles' contribution to carbon dioxide emission reduction



The contributions of the three kinds of vehicle vary across time. In the short term, the advancement in oil-saving technology for conventional vehicles will greatly promote oil-saving and emission reduction of automobiles. But in the long term, no matter it is technology advancement of conventional vehicles or development of HEVs, bottlenecks will be hit upon in oil-saving and emission reduction; in contrast, electric cars will show its strong points gradually along the way and become popular as technology develops and matures. Figure 5-7 and Figure 5-8 present in detail the different contributions of the three kinds of vehicles to oil-saving and emission reduction.

Figure 5-7: Contributions to oil-saving by three kinds of vehicles

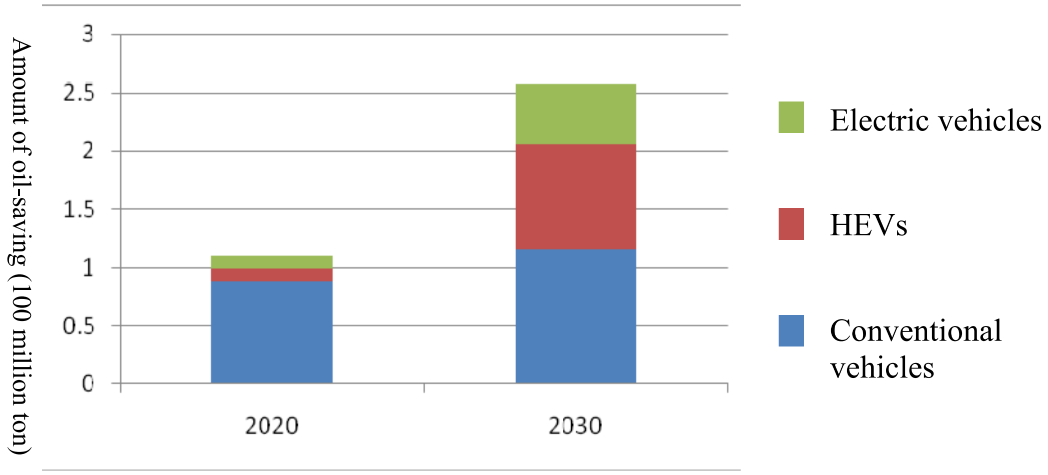
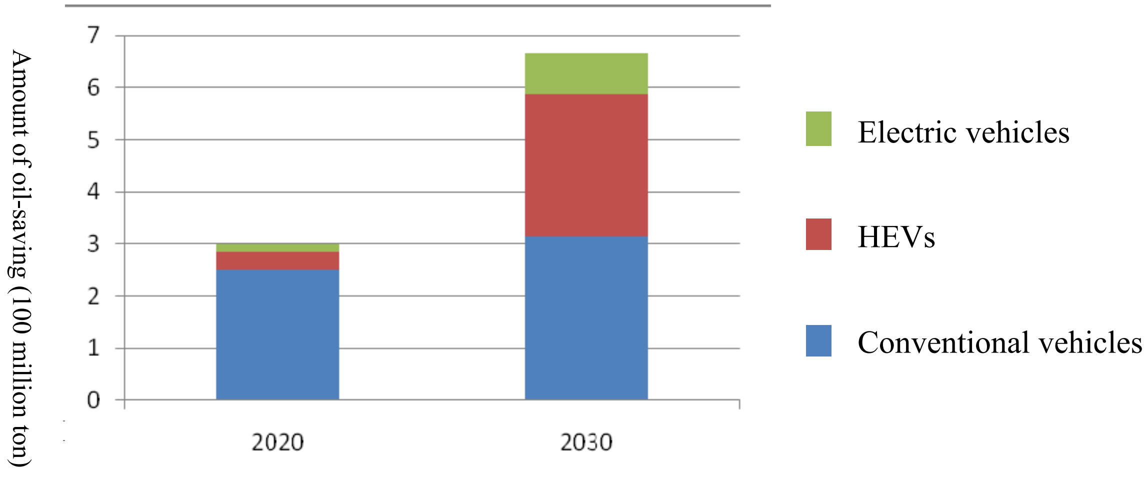


Figure 5-8: Contributions to emission reduction by three kinds of vehicle



5.3.5 The guiding principle and methods of the development of energy-conserving and low carbon energy powered automobiles

Develop energy-conserving and low carbon energy powered automobiles is the only way to a low-carbon economy for the Chinese automobile industry. According to this text's estimation, developing energy-conserving and low carbon energy powered automobiles can make substantial contribution to energy conservation and emission reduction, making the oil-consumption and carbon dioxide emission of cars be lower than the baseline by 32.7% and 30% respectively; and by 2030, with the increasing popularity of energy-conserving and low carbon energy powered automobiles, their contributions will be more remarkable, with the oil-saving and emission reduction ratio at 49.5% and 42.5% respectively.

Based on above analysis, in the short term, except relying on the technological advancement and Industrialization of low carbon energy powered automobiles, the improvement of conventional oil-fueled vehicles should also be given great attention. At present, the oil economy of our passenger vehicles is about 8 liters per hundred kilometer, 1 unit higher than Europe's average level in 2006, and 2 units higher than Japan's current level, which means that, not only from the prediction made by this text, but also from parallel comparison with developed countries, starting with the oil economy of conventional vehicles alone can bring about over 20% of oil-saving and emission reduction. In the short term, the effect of this kind of energy conservation and emission reduction will have obvious ascendancy over the contributions made by electric vehicles and HEVs.

In the long term, electric vehicles should also become the major direction for the development of the automobile industry. No matter it is the improvement of oil economy for conventional vehicles or large-scale promotion of HEVs and other types of energy-conserving vehicles, the oil-saving and emission reduction can be brought by them will finally be hampered by bottlenecks. So even in the long term, electric vehicles still remain the developmental direction for future auto industry. However, electric vehicles' demand on technology is also the most high, making it more difficult to promote than HEVs, as they lack conditions for whole-scale promotion in the short term. As a result, at least in the future 20 to 30 years, HEVs remain to be important transition models for the auto industry's march into low-carbon. In addition, China's primary energy structure need to be improved, that is, the percentage of coal fired electricity must be keep low; the development of low carbon energy, such as wind power and solar power, must be encouraged; and more diversified energy development mode must be established, so that carbon dioxide emission can be reduced in the transition process of primary energy towards electricity.

5.3.6 Policies and measures for the development of China's low carbon energy powered automobiles

1) A roadmap for China's development in low carbon energy automobiles

To determine the technological roadmap of China's development in low carbon energy powered automobiles, China should make electric vehicles as our major strategic direction for the transition of our auto industry, focus on the breakthrough in powered batteries, motors, and electric control technology, and promote the Industrialization of electric vehicles, PHEVs, so that leapfrog development of the auto industry can be achieved. Considering the long time that it must take for advanced powered battery technology to make breakthrough and headway, and that HEVs can combine the advantages of battery of internal combustion engine and realize certain degree of energy conservation and emission reduction, HEVs are excellent transitional technological plan for technological upgrading of conventional vehicles and transformation of energy power system. And combined with their relatively more mature conditions for Industrialization at the current stage, HEVs should be emphasized in the near future and be promoted in a large scale, so that the oil economy of our vehicles can be improved step by step.

2) Speed up industrial development plans for low carbon energy powered automobiles

China should speed up the formulation of industrial development plans for low carbon energy powered automobiles, and make clear our development plan, aim, focus, industrial layout, and policy measures. To promote the orderly and healthy development of the industry, China must not only actively guide the local and social investment, making full use of enterprises, especially new automobile manufacturers and private companies, but also refrain from rushing headlong into action, causing low-level investment and repetitive building. It is hereby recommended that the Industrialization of low carbon energy powered vehicles follow the step-by-step advance strategy, take into account the degree of technological advancement across different stages and the market demand, stick to a rhythm, and carry out implementation orderly. Periodical objectives should also be set out concerning the main functions of powered batteries and cost cutting. Furthermore, the construction plan of charging stations should be integrated organically with the urban plan and the electricity grid plan.

3) Set up special program for low carbon energy powered vehicles' technology and Industrialization

The biggest challenge for the development of the low carbon energy powered car industry is to form independent innovative capability. It is hereby recommended that China organize the implementation of major state-level project plan specially designed for electric vehicles technology and Industrialization, integrate short-term and long-term R&D on core technologies, take into consideration both products and projects, and speed up the formation of innovative system and sustainable innovative mechanism of the Industrialization of electric vehicles. Also China should establish special funds for the development of low carbon energy powered automobile industry, mainly supporting the R&D of core technologies of batteries, motors and electric control, begin basic and prospective study of the new generation of battery material, and realize the autonomation of equipment manufacturing, such as battery, diaphragm and cathode materials. Furthermore, China must make technological advancement in whole-set electric or control techniques, advanced internal combustion engine, high-efficiency gearbox, light weight material and other generic technologies, and make breakthrough in difficult points of Industrialization technology.

4) Establish policy mechanism that combines incentives with constraint

In the beginning period, the development for low carbon energy powered automobile industry cannot move forward without the encouragement and support of national policies. Thus, the relevant government agencies should look into the formulation of new support policies for the development of low carbon energy powered automobiles from the aspects of industrial policies, financial policies, tax policies and investment policies. This work shall include the following aspects: the implementation of average company oil economy policy and periodical restrictive measures for corporate vehicles with high oil consumption and high emission; the alteration of the past tax methods that based on emission volume and weight and the formulation of tax incentives that will be based on oil consumption; the practice of different license management between electric vehicles and conventional cars and the formulation of policy incentives based on the use of different licenses. In addition, China should also encourage the social sector to participate in the building and operation of charging facilities for electric vehicles, offering interest discounts for the building and procurement of charging stations and facilities; China must encourage the exploration of various type of charging pattern and business model (such as changing batteries) and the local governments to set up model area for the application of electric cars. China must, meanwhile, study the formulation of pricing policies for electricity that can motivate, guide and encourage electric vehicle users to make use of electricity in the lowest point.

5.4 Information and communications technology

Information and communications technology (ICT) is among the most powerful engines for the social development in 21 century. In the new situation featuring the emergence of a new generation of ICT industry and the increasing constraints posed by resource and environment challenge, ICT can not only become an important driving force of China's economic development, but also a crucial means to push forward the development of low-carbon economy and address environmental and economic issues, leading us to transform from a high-carbon society into a wise and low-carbon society.

5.4.1 The crucial role ICT plays in pushing forward the development of low-carbon economy

1) The information and communications industry consumes a huge amount of energy. Through the upgrading of technology, it can lower its carbon emissions.

In the past, it is for people to ignore the pollution issue inside information and communications industry. But in fact, both the manufacturing and the use of IC products must consume huge amount of electric power and release substantial carbon emission. In 2007, the IT research and consulting company, a global authority, Gartner pointed out that the carbon emission of IC industry account for 2% of the total emission, the same as the airplane industry, among the industry, PCs, servers and outside electronic parts are all big carbon emitters. And in 2008, the Climate Group, on behalf of the Global e-Sustainability Initiative (GeSI), and the McKinsey &Company together released the SMART 2020: Enabling the Low Carbon Economy in the Information Age report, in which similar result was reached, predicting that the emission of ICT industry itself will rise from 500 million ton in 2002 to 1.4 billion ton in 2020.

In 2007, carbon dioxide emission directly related to the production and application of the ICT industry is 190 million ton, 2.5%[107] of the total national emission. In 2010, there are 64 mobile phones every hundred person, a quick rise from 41 mobile phones every hundred person in 2007; and the Chinese netizens have increased substantially, from 180 million to 457 million. It is predicted that by 2020, 70% of the whole population will own PC, as compared with 10%. And with the large-scale increase of IC products, the carbon emission issue of the ICT industry will become more prominent. If current trend of energy efficiency remains unchanged, then by 2020, the carbon dioxide emission of ICT industry will reach 415 million ton, accounting for 4% of the total emission. If TVs and other home appliances are taken into consideration, the broad sense carbon dioxide emission by China's ICT industry will account for 5% [108]of the global ICT industry by 2020. As a result, China cannot afford to ignore this issue; China should increase technological upgrading and reduce carbon emission in the production and application process of IC products.

2) The application of ICT technologies to transform traditional industry can greatly accelerate the energy conservation and emission reduction of the traditional industries

The SMART 2020: Enabling the Low Carbon Economy in the Information Age report released by the Climate Group in 2008 pointed out that the application of IC technology in other industries can achieve 5 times energy conservation and emission reduction that of the application in the ICT industry. By 2020, ICT can reduce emission by 7.8 billion carbon dioxide, an equivalent of 15% that of the total amount under the BAU of 2020. From the economic perspective, the energy efficiency brought by ICT equals to cost cut of nearly 600 billion euro (946.5 billion dollar)

On the contribution of IC technologies to China's low-carbon economy development, considerable institutions have made predictions. The International Data Corp (IDC) believe that the carbon dioxide emission reduction potential brought by the application of IC technologies will reach 1.4 billion ton by 2020, allowing China to achieve the target of reduce emission by 40% merely by adopting energy conservation and emission reduction measures through the application of IC technologies. The World Wildlife Fund and the China Mobile Communications Corporation have co-released a study, estimating that with the proper policy, the application of IC technology can reduce China's carbon dioxide emission by 615 million ton by 2020. Xie Mengzhe and other experts wrote in 2010 that by 2020 the achievable carbon dioxide emission reduction by the use of IC technologies will be between 600 million ton and 1.4 billion ton.

Table 5-7: Energy conservation and emission reduction potential analysis of the application of IC technologies worldwide

Research institutions	Energy conservation and emission reduction potential	Energy conservation and emission reduction ratio	Major opportunity areas
GESI/Climate Group (2008) SMART 2020: Enabling the Low Carbon Economy in the Information Age		5:1 (carbon emission)	Smart grid Smart building Smart logistics Smart motor engine Dematerialization (including tele-office)
European Commission (2008) IC technologies' influence on energy efficiency	By 2020, IC technologies can save 32% of Europe's planned energy consumption.	7:1 (energy consumption) 3:1 (carbon emission)	Construction energy consumption (control of heating, ventilation, air-conditioning)
Ecofys/□WWF□ (2008) First global IT strategy of carbon dioxide reduction□ reduce carbon dioxide emission by over 1 billion ton through transformation	from 1 billion ton to 8 billion ton carbon dioxide equivalent (high, middle and low three scenarios)		In-car IC technologies (smart transportation) E-commerce and dematerialization Smart building IC technologies Application on industrial energy conservation Through smart plan to realize transformation of transportation means
	Carbon dioxide reduction target of		Building (energy management, tele-office)

	emission of these countries		conserving vehicles) Industry (dematerialization, smart motor engine)
US National Commission on Energy Policy (2009) semi-conductor technology the hope for innovation for the productive force of American energy	Through the intensive application of semi-conductor technology, the target energy consumption can be expected to be lower by 27% by 2030.	1:10 (energy consumption)	Electricity supply and management E-commerce and telecommunication Smart motor engine LED and smart illumination system Transmitter and controller The application of alternative energy Smart grid

3) ICT technology can enable China to grasp the opportunity to develop low-carbon economy, realize industrial transformation and position itself for global markets

After the international financial crisis, the world's major countries have put the development of low carbon energy and new generation of information technology industry as important strategic measures to revive the economy and occupy the international vantage point. The international IT giants take the lead in seize the low-carbon economic market. The Microsoft Corporation has taken various measures to lower its electricity consumption such as actively join in the action of energy conservation and emission reduction. Relevant agencies predicted that by 2015 the global green IT service market may reach a scale of 5 billion dollar.

Compared to traditional industry, China's new generation of information technology industry has only a small discrepancy with that of the foreign countries. China should make use of this developmental opportunity, nurture and expand the new generation of information technology industry, making use of China's huge market demand and talents base; China must also strengthen the transformation made by the new generation of information technology industry to the traditional industries, promote the in-depth integration of Industrialization and information, occupy the vantage point of technology and industrial development, realize the green low-carbon transformation of the industry, and break the green barriers posed by developed countries to upgrade our competitiveness internationally.

5.4.2 Carbon emission reduction potential of ICT technologies

1) Smart logistics

Transportation is a big and continuously growing house gas emitter, accounting for 14 % of the global emission. And the emission of logistics mainly comes from transportation and storage. The use of ICT can optimize logistics, reducing transportation emission by 16% and storage emission by 27% worldwide. By 2020, the application of ICT in logistics can reduce the world's carbon dioxide emission by 1.52 billion ton, an equivalent of 280 billion euro (441.7 billion dollar). The European countries planned to make the average carbon dioxide emission per km per new car stay at 120 grams, 25% lower than the current level. Among this, merely technical measures can reduce the emission level to 130 grams per km; the other 10 grams reduction can be realized mainly by the application of ICT, that is, smart and innovative transportation system, including smart engine management, smart vehicle safety system, smart real-time transportation management, driver information system and integrated logistic system.

The World Wildlife Fund and the China Mobile reached the conclusion by analyzing the emission reduction potential of smart logistics in China's highway logistics industry, that by offering IC service and the co-work of operating enterprises, the general public and the government, empty load rate will drop from 30% to 15%; and the biggest emission reduction opportunities of smart logistics will be 78 million tons, 128 million tons and 207 million tons respectively in 2010, 2020 and 2030.

2) Smart Building

The construction industry ranks second to manufacturing worldwide in terms of energy consumption. And the smart building technology is expected to reduce carbon dioxide emission by 1.68 billion tons by 2020, an equivalent of about 340.8 billion dollar. A North American study indicates that if ICT were applied in improving building design, construction and management, a possible 15% greenhouse gas emission reduction will be realized.

The annual electricity consumption of China's building is 4000-5000 kWh, 22%-24% of the total electricity generation. And the electricity consumption per building area is 26-27 kWh/□m2·a□, 2-3 times that of the developed countries. Because China starts up relatively late, the core technologies of smart building are in the hands of western countries and the market for smart construction products is also monopolized by foreign enterprises. Hence, our current emphasis of developing smart building should be the R&D of advanced ICT with independent IPR, the stand-alone and rapid development of domestic smart building industry. These technologies include network technologies (such as realty management technologies based on broadband, multi-network integration technologies and etc.), IC technologies (such as video conference), and smart technologies (such as NexWatch and Parking Control).

3) Smart Grid

Smart Grid utilizes in depth advanced measuring and sensor technology, ICT, control technology and information technology in various links of the grid, a modern grid highly integrated with physical grid. The grid is characterized by safety, reliability, economy, high-efficiency, cleanness, environmental protection, smart self-healing and friendly interaction, the means to realize fundamental reform in the electricity industry. Through the smartization of grid, the carbon dioxide emission will be expected to be reduced by 2.03 billion ton by 2020 worldwide, an equivalent of 124.6 billion dollar.

Smart grid has great strategic importance for China's development of low-carbon economy. According to the estimation made by study, if China could basically complete the smart reform of traditional grid by 2020, as against the situation that smart grid was not adopted, by 2020 energy consumption equivalent to that of the burning of 220 million ton standard coal can be reduced, which also means the emission nearly 500 million ton carbon dioxide, 4.9 million ton, 2.2 million nitrides and 380 trillion ton of TSP can be reduced (see Table 5-8).

Table 5-8: The energy reduction & emission reduction efficiency of the development of smart grid in China (2020, unit: trillion ton)

Specific links	Energy	Carbon dioxide	Sulfur dioxide	NO_X	TSP
Line loss reduction	210	445	5	2	4
Fuel consumption for electricity generation reduction	6100	12932	134	61	104
Electricity consumption reduction	12000	25440	264	120	204
Low carbon energy and renewable energy	4000	8480	88	40	68
Electric vehicles	--	2100	--	--	--
Aggregate	22310	49397	491	223	379

At present, China's smart grid remains to be at stages of exploration and attempt; and because smart grid has strong dependency upon ICT, its future development will mainly be represented by leapfrog advancement of relevant technologies. The technologies need R&D and improvements are as following: first, communications and sensor technology; second, accurate parameters measurement technology, for the understanding of the real-time operation of the grid; third, automatic control technologies; fourth, decision support technology.

4) Smart motor engine

According to the analysis by the Climate Group, if China begins to make full use of ICT to reform the motor engine and improve the energy efficiency of industrial equipments, then by 2020 the world can expect a 970 million ton carbon dioxide emission reduction, saving 107.2 billion dollars.

To realize smart motor engine has more active influence in China. Because the manufacture industry is the growth engine for China's economic growth, and also a major energy consumer; since 1996, its energy consumption remain 70% or above of the total energy consumption. Among this, motor engine accounts for 70% of the total energy consumption of the manufacture industry, with an energy efficiency rate 20% lower than that of the western countries. The predictions indicate that, without improvement and immediate action, by 2020, 10% of China's emission (2% of the global emission) will be from motor engines; if smart reform is implemented, then a carbon dioxide emission reduction of over 200 million ton can be realized.

5) Smart Work

Smart work means to work with the assistance of advanced communications tools such as the internet to avoid work hour traffic jam, inflexible work places and numerous other business travel issues connected with traditional work pattern, so that good economic benefits can be brought to the enterprises, and environmental benefits be created for the general public. According to predictions, by 2020, if 5% commuters can start tele-work, 15% of business travel can be replaced by e-conference, the global carbon dioxide emission will be reduced by 100 million ton. With the ever wider spread of tele-work and e-conference, the global can benefit from at least 3 billion tons of carbon dioxide emission reduction in the next few decades.

Based on statistics released from the WWF and the China Mobile, the biggest emission reduction opportunities for Chinese tele-work's emission reduction potential will be an equivalent of 298 million tons and 340 million tons of carbon dioxide in 2010 and 2020 respectively. And the biggest emission reduction opportunities for e-conference's emission reduction potential will be an equivalent of 12 million tons and 123 million tons of carbon dioxide in 2010 and 2020 respectively

5.4.3 Problems and challenged faced in the application of ICT to promote low-carbon economy

In September, 2010, with the deliberation and adoption of Decisions on Speeding up the Nurturing and Development of Strategic new industries by the State Council, the new generation of IC industry has became one of the strategic new industries in China. To apply ICT on traditional energy-consuming industries, from one aspect, can effectively reduce carbon emission through modern information technology, so as to realize the goal of energy conservation and emission reduction; from the other aspect, pose higher demand on IC industry itself. As a result, to apply ICT on traditional industry at present, China must first address certain problems of various aspects in the IC industry:

1) The R&D and manufacturing capability of sensor equipment and smart control equipment is relatively weak.

The sensor equipment and smart control equipment are the material carriers for the application of information technology; and the information technology's role in traditional industries is mainly represented in the application of sensors, routers and other equipments. The application of Internet for Things, for example, can improve the accuracy and precision management of traditional industries, but the development of Internet for Things need the support of RFID chips, infrared sensors, laser scanners, GPS and other information and sensor equipments. At present, as compared to the international advanced level, China is still relatively weak in the aspects of R&D and manufacturing of information technology infrastructure; China have to increase investment manually, intellectually and financially, so as to further push forward the R&D and production of the new generation of information technology facilities.

2) The building of Internet still need to be strengthened

The application of ICT on the traditional industries has to rely on the support of a strong and stable Total Access Communication System (TACS). So China needs to strengthen the building of next generation of internet based IPv6, support the development and application of the next generation of internet core technology and key software, push forward the process of Industrialization, and speed up the building of the next generation of high-speed broadband network.

3) The system solving plan needs to be improved

For sensor equipment, routers and other smart control equipments to realize the automatic management and control function in the different production sectors in the traditional area, one precondition must be met, that is, adopting a consistent data format to make sure the compatibility of different facilities, so as to realize smart energy conservation control based on the calculation of platform and smart control system, which is provided by the smart analysis. Thus, to push forward the application of information technology in the traditional industries, China should actively move forward the unification of new type internet standard and the data interface standard, and make out a systemic solution plan.

5.4.4 Policy measures to make use of ICT in the development of low-carbon economy

1) Make clear the strategic position and increase policy support

We must treat ICT as important measures to build an energy-conserving and environmental friendly society, break the hurdles in the aspects of system, mechanism, technology and fund, and expand the financing means and relevant financial service that fit for the development of green ICT industry, and push forward the innovative development of ICT in the low-carbon economy.

2) Insist on independent innovation and reinforce the technological R&D

China should view low-carbon development as an important area of the development for the IC technologies, increase R&D, strive forth to realize the leapfrog development of IC technologies in the development of low-carbon economy, and occupy in advance the vantage points of international industry and technology.

3) Launch the model application and improve the assessment mechanism

China should select the right key areas, carry out pilot/demonstration programs actively, establish an assessment mechanism for the pilot programs during the whole process, conduct analysis on the applicability and market demand of ICT technologies that cater to the development of low-carbon economy, overcome the developmental bottlenecks nonstop, so as to push forward R&D and popularization of our green technologies and products.

4) Reinforce multilateral cooperation and consolidate the formulation of international standards

The development of IC technologies appropriate for the development of low-carbon economy is related to the formulation of telecommunications standard, products standard, technical requirements and other relevant standards. China should strengthen the guidance of the government, make use of the trade associations and industrial alliances, fully motivate the enterprises, especially the leading ones, actively formulate and perfect the technical standard system, research into the products' green manufacture standard system, gradually improve the industrial standard into the national level, and step by step influence the formulation of international standards.

5) Reinforce the fostering of talents and strengthen the building of talents group

China must improve patterns like further education and job change training, so as to foster and nurture talents with specialized knowledge background and techniques. Through close cooperation with institutions of high learning, such as program cooperation, technology R&D and consultancy service, China can make full use of incubators inside scientific parks and universities, driving production with learning and research and pushing forward the construction and development of ICT.

6) Open up international cooperation and explore new cooperation pattern

China should open up wide-range cooperation with governments, international corporations and high-tech enterprises of advanced countries, make use of the enormous potential of the development of China's low-carbon economy, and speed up the application and transformation of advanced international technologies in China, so as to lower the time and capital cost for the development of China's green ICT industry, improve the technological and management level, and improve the overall strength of China's development of green ICT industry.

5.5 Bio-industry

5.5.1 The basis and prospect of the development of China's bio-industry

1) A relatively good basis for development

China leads among developing countries overall in terms of life science and bio-technology; our Industrialization capability of bio-technology has improved substantially; the bio-medicine and bio-agricultural sectors have reached a certain scale; numerous new bio-products and industries develop rapidly. In addition, China is a country with a most rich bio-resources and talents engaged with bio-technology research both from abroad and domestically.

2) A broad prospect of the market

Based on conservative projections, by 2020 China's bio-medicine market in the broad sense will reach a scale of 4 trillion RMB, bio-manufacturing 1 trillion RMB, bio-agriculture 500 billion RMB, bio-energy 3000 billion RMB and bio-environmental-protection 100 billion RMB; overall, the market scale of the bio-industry is about 6 trillion RMB.

3) In a period of strategic opportunities

The world bio-industry has not formed monopoly pattern that the market is controlled by few international corporations. The China's bio-industry has the smallest gap in terms of technology, talents and scientific research base, and is in possession of rich bio-resources, making it the most promising area to realize leapfrog development.

5.5.2 The contribution of developing bio-industry to the Industrialization of low-carbon industry

Bio-economy is a green, low-carbon and sustainable model of economic development, especially because the raw material for bio-manufacturing comes from absorbing carbon dioxide of the atmosphere; And with its product or consumption in the form of the storage and reuse of carbon dioxide, it can be viewed as a circular flow featuring the return to nature.

The bio-refining technological system in the bio-manufacturing industry is a new manufacturing model that uses renewable bio-resources as raw material to produce a series of energy and industrial products. Sugar, fat, uneatable biomass, organic waste and even industrial exhaust gas and carbon dioxide can serve as raw material for bio-refining to produce chemical products similar to that produced by oil-refining, including basic chemical material like tri-ene, tri-benzene, solvent, surfactant, chemical intermediate, high molecular material like plastic, nylon and rubber; a large array of fine and specialized chemicals such as chemical alcohol, binary acid, Polyethylene terephthalate (PET) and polyamino acid have abandoned the traditional oil path, with bio-plastic, bio-fiber and bio-rubber gradually entering into the market. And it is estimated that 90% of the traditional oil chemical products can be made by bio-refining. According to a 2009 strategic report, Administrative Program about

Facing the Bio-economy in 2030, by 2030, there will be 35% chemicals and other industrial products from bio-manufacturing, with bio-manufacturing contributing to 39% of the bio-economy, overtaking bio-medicine and bio-agriculture. Meanwhile, due to the use of renewable resources, the life cycle of bio-manufactured products has greatly reduced the emission of carbon dioxide. As predicted by the WWF report, by 2030, the global industrial bio-manufacturing technology can reduce 1 billion tons to 2.5 billion tons of carbon dioxide annually and has more long-lasting emission reduction potential. Therefore, bio-manufacturing can redress the disadvantages of the oil chemical way of manufacturing and promote the production of heavy chemicals and high molecular material to transform into bio instead of oil, so that the long-term sustainable production of the products, the simplification of production process and the reduction of energy consumption and material consumption in the process of production, and the abatement of environmental pollution can be realized. In other words, it make great strategic sense for the sustainable development and China's industrial economy, less reliance on oil resources and reduction of carbon dioxide that we develop bio-manufacturing, increase the percentage of green, low-carbon and renewable bio-chemical production, and reorganize the material structure of oil chemical industry.

5.5.3 Problems need to be solved urgently for accelerating the development of bio-industry

1) The week independent innovation capability

Of the global bio-technology patents, the US, Europe and Japan account for 59%, 19% and 17% respectively; in contrast, developing countries including China account for only 5%. Among the 380 genetic project medicine and genetic project vaccine products of 25 types from 13 classes that has been approved to enter the market, only 21 products of 9 types from 6 classes are original, with the rest all copies.

2) Industrial organization

The bio-enterprises generally are of small scale, with serious shortage big bio-enterprises. The industry's low concentration degree, almost identical organization and disorderly competition have lead to low profitability of the enterprises, weak accumulation capability, so that they are hard to achieve positive development.

3) Lack of funds

China's annual R&D expense of bio-medicine cannot reach that of a single international medical company. And China lacks a domestic risk investment mechanism for starting up an enterprise, making it hard to acquire financial support during the initial stage and Industrialization period of the enteriprises.

4) Poor commercialisation of scientific results

Because technology and economy are not closely knitted and the practicability link of "pilot, expansion and integration" is weak, the Industrialization rate of China's bio-technology outcome falls short of 15%, with that of the western district lower than 5%.

5) The market environment needs to be standardized

The circulation order of the medical market is in chaos. The procurement and bidding process for medicines are not standardized. The product standard and technical standard of bio-energy, bio-agriculture and bio-based material are not systemic. And what's more, the technological products market is not mature.

6) Inappropriateness of relevant system and mechanism

The reform of systems and mechanisms like scientific research and innovation, medicine and health care, investment and financing, products evaluation, products pricing, market access of GM products, government procurement and enterprises assessment are lagging behind, unable to satisfy the need of large-scale Industrialization.

In addition, some issues, such as the loss of biological resources, the encroachment of alien species, pose great hidden dangers to bio-safety.

5.5.4 The strategic aim and main thoughts on accelerating the development of bio-industry

1) Strategic aim

By 2025, the global bio-industry will enter the mature stage. This period will be marked by the following features: substantial improvement of biology's application on the industrial area, China's bio-technology achieving world's advanced level, key technologies with independent IPR, major bio-technology products that can satisfy the basic need of the general public, the bio-industry becoming one of the important pillar industries of the national economy, the emergence of an array of international bio-enterprises that are in possession of world's cutting-edge innovative capability, the export sector of bio-industry taking a large share of the global market, and China's becoming a bio-industry giant, bio-technology leader and center of bio-economy globally.

2) Key issues for biotechnology

i. Further pay attention on the development of bio-industry from the strategic vantage point of the state

It is imperative that China speed up the formulation of State Plans for Medium and Long-term Development of Bio-industry (2010-2030), even the Plans for Medium and Long-term Development of Bio-economy, and make clear that the industry become state strategic industry.

ii. Focus on making breakthrough and implementing in advance an array of key, core and cutting-edge bio-industry technologies

An array of major programs that are mature and have good market prospects, especially part of the mature technologies of the areas such as bio-agriculture and bio-medicine should be selected in the short term to accelerate the advancement of Industrialization, with the focus on pushing forward innovation on key technologies, techniques and products. As to technologies already industrialized, their application shall be enlarged. Meanwhile, we must study the economic society and other sectors' demand for the bio-industry, implement and develop in advance an array of cutting-edge bio-technologies, original innovation for the next generation of technology and integrated innovation.

iii. Improve independent innovation capability of the bio-industry

It is crucial that China support the strong bio-enterprises to establish high-level R&D institutions, reform or set up state-level engineering laboratories, engineering research centers, and improve the engineering and systemic integration capability of findings of scientific research. China should also push forward the industrial capacity building, such as state-level bio-technology public laboratories, pilot bases and financing platforms, and talents cultivation platforms, encourage the formation of high-end generic technology platform with strong enterprises as the core, support higher educational institutions and science research centers and push forward the building of bio-industrial technological innovation alliance. Furthermore, it is important that the systemization degree of combining industry and education be increased, effective implementation mechanism that lead by enterprises and joined together by higher educational institutions and science research institutions be established, so that cooperation on applying bio-technological findings can be realized.

iv. Induce relevant elements to converge on bio-industrial bases and forge a high-efficient bio-industry chain

To speed up the fostering and development of competent bio-industrial regional clusters, China should select districts with good industrial base, strong innovation capability, high level of marketization and more openness to build several state-level bio-industrial bases with unique styles based on the principles of overall planning, bringing into full play comparative advantages, differentiated guidance and steady improvement. Encourage and guide the bio-enterprises and the relevant bodies in the upper and lower reaches to cooperate in good way, realize rational division of labor and effective integration, optimize the industrial chain, reduce the operational cost of industrial chain to the utmost, and improve their response capability to the market to the utmost.

v. Foster and develop a series of strong bio-enterprises

Following the principle of “government guidance, market mechanism and leading enterprises integration”, China should support the leading enterprises to grow bigger and stronger, encourage the merger or acquisition of R&D institutions with core technologies domestically and worldwide, also the merger and restructuring with promising enterprises domestically and worldwide, and speed up the nurturing of domestic bio-enterprises leaders that have relatively stronger innovation capability and international competitiveness. China must also support the development of several high-tech medium and small bio-manufacturing enterprises that have special technical features and flexible mechanisms. China should assist the big bio-distribution enterprises, encouraging them to explore actively the global market based on the domestic market. In addition, China must support the service outsourcing enterprises to integrate to the global R&D chain of the bio-industry.

5.5.5 Policy measures to expedite the development of bio-industry

1. Strengthen leadership and group coordination

It is recommended that industrial leader group be set up to coordinate and adjust the developmental targets and policies of the bio-industry, increase the synergy among different sectors, and make use of good policies and administrative resources to develop the bio-industry.

2. Integrate government resources and strengthen support efforts

China should integrate the Government Technology Plan Fund, the Scientific Research basic condition building and other Funds, increase financial input, and set up the State Bio-industry Development Fund. Certain amount of subsidy can be grant to bio-products that faces high costs in the initial stage of Industrialization or cannot fully realize marketization, and relevant preferential policies must be studied and formulated by combining the reform direction of state taxation. As to bio-products for quarantine urgently needed by the state, zero tax rate can be implemented. And bio-enterprises registered inside China can benefit from preferential policies on corporate income tax; the newly established bio-enterprises, the first two years since acquiring profits, can enjoy a preferential policy on income tax, the so called Two Exemptions and Three 50% Off policy.

3) Improve the financing environment and widen the financing channels

The establishment and development of bio-technology business-starting & investment institutions and industrial investment fund shall be encouraged. Bio-enterprises to raise capital through the capital market should be supported. Adopting the principles of "independent appointment, independent standard and independent assessment" in the domestic venture exchange, China should increase the percentage of direct financing, make full use of the state policy banks, support the enterprises to lend money from the bank using patent technologies as warranty, and give full support to bio-enterprises with independent patent technologies and promising market prospects. The financial products should also be specially studied and Bio-industry Investment Fund should be established. Risk investment and state-level technology-based SMEs innovation fund shall be encouraged, with the focus on SMEs that conduct development of biological technologies and the Industrialization of research findings in China.

5.6 Advanced materials

New materials generally refers to newly emerged and developing materials with superior performance and special functions that the traditional materials do not have, or traditional materials with obviously improved function or new function that was a result of new technologies, techniques and equipments. They can be divided into metal new material, non-organic non-metal new material, organic new material and composite new material according to physical and chemical attributes; advanced function material, high-efficiency structure material and structure-function integrated material according to function; electric information material, space and aeronautic material, low carbon energy material, energy conserving and environmental material and bio-medicine material according to application area.

5.6.1 The new material industry has a broad market prospect

The development of the current economic society has increase rapidly the demand for low-cost, high efficiency, smart, light weight, and green and environmental friendly new materials. China, with the upgrading and reform of traditional industries, the rapid development of new high-tech industry, the daily improvement of people life, is in the important stage of accelerated Industrialization and urbanization now, which provide the rapid development of the new material industry with enormous demand potential.

Upon calculation, the scale of China's new material industry in 2008 reached about 600 billion RMB; among it, chemical new material accounts for 110 billion RMB; non-organic non-metal material 70 billion RMB; black metal new material 120 billion RMB; non-ferrous metal, precious metal and rare earth new material 230 billion

RMB. During the twelfth five-year plan and a long period in the future, the new material industry will witness an accelerated development, with an average increase rate of over 20%. By 2020, the output value of the new material industry will exceed 5 trillion RMB.

5.6.2 The influence of new material industry on low-carbon Industrialization

The new material industry, as the basis and leader of the high-tech industries, has great importance for China to realize coordinated development between resource, energy and environment, optimize the industry structure and achieve sustainable development of the national economy. The new material industry's influences on low-carbon Industrialization can be divided into the following aspects:

Firstly, new material can assist and support the strategic new industries, pushing forward low-carbon Industrialization.

The development of energy-conserving & environmental protection industry, low carbon energy industry, low carbon energy powered vehicles, high-end equipment manufacturing and bio-industry must be backed up with the development of new material industry, for example, the development of solar power must be supported by the development of polycrystalline silicon industry. The key to developing low carbon energy powered vehicle lies in battery, and the key of battery lies in material. And also taking another example, the materials of high-end equipment manufacturing rely on advanced structural materials (part of the new material), such as high-quality special steel, new type alloy material and engineering plastic. To improve the developmental level of carbon fiber, aramid fiber, UHMW polyethylene fiber, and other high performance fiber and compound material and to conduct research on general basic material (part of the new material industry) such as nanometer, superconductivity and smart material, can provide broader potential space for the further development of high-end manufacture.

Secondly, the close integration between new material industry and traditional industry can step up the low-carbon Industrialization. For example, light weight and strong new structural materials, including high-performance compound fiber material and light metal material (such as aluminum, magnesium, titanium and their alloy) have great advantage of energy conservation and emission reduction in aerospace, automobile, communications, transportation, ocean, construction and other industries.

Thirdly, the reconstruction of new material can improve the quality of building materials, realizing construction energy conservation of low emission reduction. Every year, China's housing building area averages about 2 billion square meters; it is predicted that by the end of 2020, the newly increased housing area will reach nearly 30 billion square meters. If the current construction scale and level of energy consumption in construction remain unaltered, then by 2020, the annual energy consumption will be equivalent to 1.2 trillion kWh of electricity and 410 million tons of coal, almost three times that of the current level. Meanwhile, among the energy consumption of construction, the energy consumption resulting from heat loss of the outer protective structure reached as high as 70% or above, with windows and outer layer of wall accounting for 50% and 28%. The building material, in a large degree, determines the energy conservation efficiency of the buildings. That is why new building materials, with their high-performance, multi-function and smart features, are crucial for the energy conservation of buildings.

5.6.3 The main challenges in the development of China's new material industry

1) Separation between manufacture, study and research makes it hard to utilize scientific findings.

To view from the scientific area of new material, China, through decades of accumulation, has acquired relatively high scientific R&D level of new material and is very active in the R&D of new material. Among the annual National Technology Award, new material projects take a large share and their research findings occupy important position. At present, the theses on new material technology published in China ranked among the top worldwide. But from the degree of Industrialization, China can see that China still fall far behind the developed countries in the new material area, especially testified by the slow and ineffective Industrialization and commercialization of high-tech outcomes. On one hand, this owes to the fact that our scientific research mainly depend upon higher education institutions and scientific research institutions, which pay attention to the breakthrough on the D&R of new materials instead of Industrialization; on the other hand, the enterprises, some restricted by inappropriate infrastructure or insufficient funds, some inexperienced and have no long-term development plan, are more dependent upon the already well-established technologies and not enthusiastic about cooperating with the universities for the realization of Industrialization; as a result, a lot of scientific findings stagnate at the stage of the laboratory, extremely difficult to realize Industrialization.

2) The market is dominated by state owned enterprises and government agencies, making it risky and costly for the private sector to invest.

Since the beginning of China's new material R&D, it is dominated by the government. Because state-owned capital is to be supported and encouraged tacitly when the government makes developmental plans for the new material industry, the policy incentives can hardly benefit private capitals engaged in the R&D and Industrialization of new materials, increasing the investment risks of the private capitals and damping the activity of private capitals to reform and innovate, which, as a final result, hampers the readjustment of the patterns of economic development of different industries. So, China's establishment and improvement of the investment and financing policy mechanism of new material industry, and equal treatment of all capitals become key factors for the rapid expansion and development of the new material industry.

3) The technological level is low and the industrial chain is weak

Against the expansion of the new material industry, the technological contribution of China's new material industry continues to be lower, especially in 2005, when the output increases exponentially without improvement of efficiency. Because a huge amount of new material enterprises have adopted single pattern of extensive expansion, investing huge amount of capital in the short-term while the contribution rate of intensive expansion that relies on the technology advance underwent a sharp decrease.

4) The industry is highly dependent upon foreign markets.

On the one hand, the current new material industrial market has not been developed sufficiently and the demand is not strong. On the other hand, because domestic enterprises do not have strong intensive processing capability; the shortage of middle to high range new material remains to be the main feature of domestic new material industry; and China still has huge import substitute demand domestically. Take the production of polycrystalline silicon, used in solar panels, as an example, China have to import the raw materials from abroad and then export the products, playing the role of processor, with both ends taken care by the foreign countries.

5) Policy support is not strong enough and a long-term developmental plan is needed.

Although the state has continuously concerned and supported the new material industry, the strong independence of every policy supported plans and insufficient relatedness have greatly undermined the implementation result of these policies. And the participating parties do not communicate and exchange ideas on the problems occurred in the process of policy implementation, casting bad influence over the industrial layout and effective configuration of resources. In addition, the policies were introduced untimely because, on one hand, the information cannot be communicated quickly and smoothly, making it difficult to reach the higher-level government; on the other hand, the government lacks long-term plan on the beginning period of the new material industry, having no clear picture of the inherent issues, so that the healthy development of the industry is greatly affected.

6) The accreditation system and industrial standards are not well-established.

The management of China's material industry is in the hands of different parties, making the management mechanism relatively disorderly. And many industry standards were made by different government agencies themselves instead of the industrial associations according to the international standards; and the similarity of enterprises and the need to take part in global competition were not fully considered, causing real troubles to enterprise. Furthermore, the management role of the government has been weakened by the departmentalization of power control, leading to ineffectual communication and cooperation between enterprises, schools and R&D institutions, the insufficient development of effective mechanism that combines production, study and research, causing the disjoint between R&D development and the market, which in real senses also causes the difficulties in formulating industrial standards.

5.6.4 General ideas and developmental target of the development of the new material industry

China should stick to the demand of the development of national economy and the society, taking as the main strategy to push forward economic structural adjustment and upgrading of traditional industries, focusing on the improvement of independent innovation capability of new material industry, making breakthrough in high-performance new materials that has a broad scope and highly demanded by the major projects of the state. And China must push forward the development and commercialization of new material industry that has good market prospect, strong leading power, good development base and independent IPR, and promote the integrated development of new material industry and traditional raw material industry, so as the international competitiveness of China's new material industry can be improved substantially.

2) Developmental target

Till the end of the twelfth five-year plan, China must establish a new material industrial system that is strong in dependent innovation capability, have relevant scale and vivid features, build several industrial bases for new material with prominent advantages and self-sustained, and foster a series of pioneering enterprises that have strong innovation capability and core competitiveness. China also need to make sure that new materials can basically satisfy the need of national economic construction and national defense industry, and endeavor to build China into a new material giant instead of a material country.

5.6.5 Policy measures to speed up the development of new material industry

1) Developmental strategies for the new material industry

The state should make out clear developmental strategies for the new material industry and determinate the direction of the development of the new material industry. So, based on the past relevant plans and schemes, China should, with a global perspective, start from the national developmental strategy and carry out top design, giving comprehensive consideration to the development, supply and use of new materials. China shall also make long-term plan appropriate for the development of new material industry, set out developmental goals for future new material industry, and propose core technologies and equipments that could address the bottleneck of the development of new material industry, making out thoughts, breakthrough direction, developmental means, methods, and policies that can solve the core issues for implementing and managing industrial standards.

2) Integration between innovation in basic research to improve the commercialization rate of scientific findings

New materials have dense technology and knowledge, fast product renewal rate, and intense competition, so China must improve the integration of basic research innovation and Industrialization, focus on absorb and introduce advanced technologies, conduct independent innovation, and gradually realize the integration between R&D, production and application. In addition, new material is now developing towards the direction of high-performance, multi-function, compound, smartness and lost-cost; so strong basic research is needed as guide for the process of R&D and manufacturing, including the support of various technologies.

3) Reform governmental management model of industrial innovation, and maintain sustained innovation capability of the government

At present, local governments, when promoting the development of new materials, pay primary attention to acquire GDP increase and relevant tax income from the investment of enterprises, putting the industrial innovation in subordinate position. China can attract advanced enterprises from abroad, but are unable to transplant and follow the regional innovation system that offers sustenance and development to them. From this we can gather that to realize effective regional innovation, China cannot simply resort to the accumulation of advanced elements from different regions, instead, China have to depend on effective coordination and efficient operation that has regional characteristics and is systemic. As a result, the responsibility of regional governments is to set it as the core to deplore the, foster and create regional features, guide, foster and strengthen the exchange, communication and networking of innovation identities. Governmental innovation means to adjust itself for the maintenance of sustainable industrial innovation, and provide sufficient support for the maximization of industrial innovation.

4) Increase support to the investment of private capital

While making out and implementing the developmental plans for the new material industry, China must pay attention to the capital and R&D power the private capitals have accumulated over the decades, increase the number of preferential policies for them, grant them space and policy support to fully make use of their power, and bring into full play the regulating capability of the market system, which is also consistent with the principle that the scale efficiency and competition efficiency must be consistent.

6 A POLICY FRAMEWORK FOR LOW-CARBON INDUSTRIALIZATION

Low-carbon Industrialization is the core of developing a low-carbon economy, and also a main approach to promote the transformation of China's mode of economic development. According to the development target and main approach of low-carbon Industrialization identified based on the challenges China faces in the process of industrial transformation, and drawing upon international experience, China should advance the low-carbon Industrialization endeavour from multiple policy areas, including developing development program of low-carbon Industrialization, improving pricing systems for energy and principle resources, constructing fiscal and taxation policy systems in promoting low-carbon economy, improving market mechanism and strengthening technological innovation and application etc, thus to shape an institutional mechanism and policy environment favourable to the development of low-carbon Industrialization.

6.1 Components of the policy framework

6.1.1 Logic behind the policy framework for promoting low-carbon Industrialization

Thoughts behind the policy framework for promoting low-carbon Industrialization are as follows:

(1) Formulate relevant policies according to major approach options. There are mainly two approaches to promote low-carbon Industrialization, namely technology improvement and restructuring, which are reflected specifically in improving energy efficiency, enhancing comprehensive utilization rate of resources, strengthening technological R&D, promoting industrial restructuring and upgrading, increasing the rate of added value of products and optimizing structure of energy supply. Therefore policies to promote low-carbon Industrialization should be formulated according to these approach options.

(2) Specific approaches to construct the policy framework for low-carbon Industrialization: firstly, eliminate relevant policy measures unfavourable for low-carbon Industrialization. Efforts should be made to rescind current policies unfavourable for low-carbon development or sustainable economic development according to the requirements of low-carbon Industrialization; secondly, improve and consolidate relevant current policies. Efforts should be made to improve and consolidate current policies related to low-carbon Industrialization according to new requirements; thirdly, formulate new policies to promote low-carbon Industrialization.

Efforts should be made to work out new policy measures that meet the requirements of low-carbon Industrialization in reference to the shortcomings of current policies.

(3) Select policy measures. In promoting low-carbon Industrialization, different policies have different spheres of function and may influence one another. It is therefore necessary to appropriately select means of policy, coordinate different policies and foster synergy to avoid contradiction and conflict that weakens policy effect.

(4) As a tool kit of multiple policies, policy framework should coordinate all policies. Firstly, to promote low-carbon Industrialization, government and market mechanism should work together, which means that on the one hand, government should formulate relevant laws and economic policies; on the other hand, the use of market mechanism should be valued, and more importantly, government policies should promote the shaping of market mechanism and guide it to play its due role, thus promoting low-carbon Industrialization more effectively; secondly, incentives and binding measures should work together. That is to say, economic incentive policies and binding policies (including standards etc) should be used jointly to better realize accommodation of the two.

6.1.2 Policy options for promoting low-carbon Industrialization

In order to address issues including the great difficulty in transforming the mode of high-carbon Industrialization, overall low level of technology, relatively weak basis for technological innovation, unsound market mechanism and defects in policies related to price, finance and taxation, laws, regulations and standards etc, and in reference to international experience of low-carbon Industrialization and China's actual situation, the main policies to promote low-carbon Industrialization are as follows::

1. Policies related to laws and systems, which mainly include formulating development plans for low-carbon Industrialization and improving systems of laws, regulations and standards.

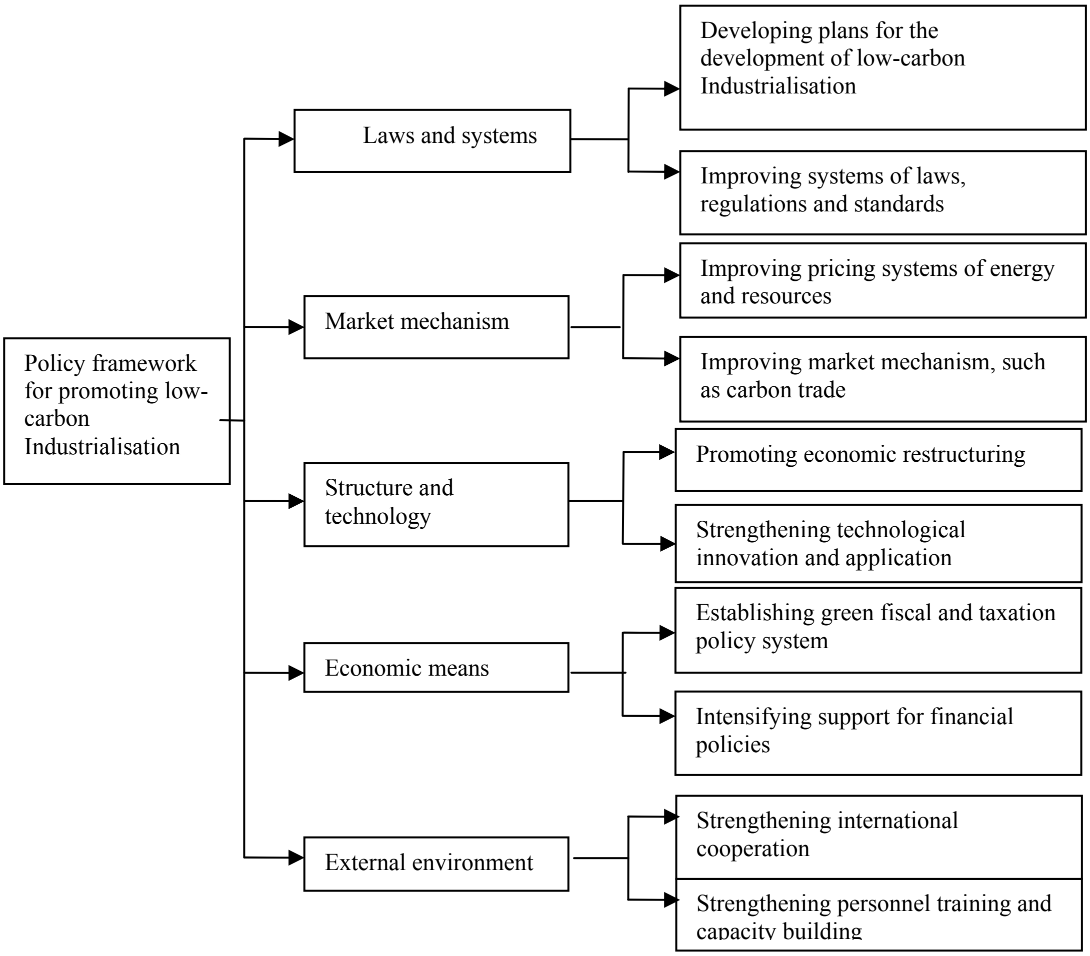
2. Policies related to market mechanism, which mainly include improving pricing systems of energy and principle resources and market mechanism, such as carbon trade.

3. Policies related to restructuring and technological innovation, which mainly include promoting economic restructuring and strengthening technological innovation and application.

4. Policies related to economic means, which mainly include speeding up the establishment of green fiscal and taxation policy system and intensifying support of financial policies etc.

5. Policies related to external environment, which mainly include strengthening international cooperation, personnel training and capacity building.

Figure 6-1: China's policy framework for promoting low-carbon Industrialization



Source: LCIS Task Force analysis

6.2 Policies for promoting low-carbon Industrialization

6.2.1 Planning the development of low-carbon Industrialization

By setting out development plans, low-carbon Industrialization can be identified as a main approach to promote the transformation of mode of economic development; and its development strategy can be arranged in a broader context.

1. The form of the low-carbon Industrialization development plan.

The development plan can appear in two forms: firstly, reflect the content of low-carbon Industrialization in the overall plan for national socioeconomic development or the plan for the development of low-carbon economy; secondly, formulate dedicated development plan for low-carbon Industrialization according to the above overall plan when conditions permit. Through planning, the phased development targets, development approaches, main areas, policy support of low-carbon Industrialization etc could be identified.

2. The targets for the development of low-carbon Industrialization.

Under the action target and binding target of China in controlling the emission of green house gases (GHGs) that cutting CO2 emissions per unit of GDP by 40-45% in 2020 from the level of 2005, further consideration could be given to identifying emission reduction targets for the secondary industry, setting emission reduction targets for some sectors (high energy-consuming sectors or energy intensive sectors) (setting specific targets for the development of low-carbon Industrialization according to research findings in other parts). In addition, requirements for industrial restructuring and technological innovation should be identified.

3. Main approaches, key areas and policy guarantee for the development of low-carbon Industrialization.

The main approaches and key areas should be identified in the development plan of low-carbon Industrialization; based on that, safeguarding mechanisms such as relevant economic policies should be formulated to ensure the smooth implementation of the plan.

4. Relationship between the development plan of low-carbon Industrialization and other plans.

The development plan of low-carbon Industrialization should align and coordinate with plans such as “the twelfth five-year plan and the following overall plans”, “energy plan”, “plan of technological innovation”, “plan for emerging strategic industries” etc, thus to shape a operable development policy for low-carbon Industrialization.

6.2.2 Economic restructuring

Without transforming the mode of economic development, a genuine low-carbon economy could hardly be built. Optimizing industrial structure through eliminating backward production capacity and developing modern service industry and emerging strategic industries will promote the development of low-carbon Industrialization.

1. Eliminating backward production capacity

i) Establish an appropriate exit and compensation mechanism for backward production capacity. Efforts should be made to continue to implement the fiscal incentive policy for the elimination of backward production capacity, establish an appropriate exit and compensation mechanism for backward production capacity and properly handle the workers placement, conversion of production and debts dissolving resulted from the elimination of backward production capacity. Differentiated regional fiscal support policies should be adopted in consideration of the uneven economic development and financial strength of different regions. To be specific, for the underdeveloped regions, the central finance should further scale up the special funds and adopt special transfer payment to incentivize the elimination of backward production capacity. For regions where conditions permit, supporting fund could be arranged according to their actual situation so as to increase support. For developed regions, special funds or fiscal incentive funds could be arranged according to local financial strength and the actual needs of the elimination of backward capacity.

ii) Use various policy measures together. Efforts should be made to integrate economic, legal, environmental and all other necessary administrative tools and make full use of the current policies such as fiscal subsidy, favorable taxation, land development transfer, and financing, address asset compensation, personnel placement and other issues related to the elimination of backward production capacity and support all regions to conduct relevant work.

2. Developing emerging strategic industries

i) Set up a special fund for the development of emerging and strategic industries. The central finance authority should integrate the current various special funds for industrial development, industrial R&D fund, research-into-use fund, electronic development fund, integrate circuit R&D fund and other funds that could be merged and set up a fund for the development of strategic and emerging industries; meanwhile, financial input should be increased to scale up the special fund. The central government should set up a piloting fund and scale it up. Funding priority should be given to the infrastructure inside bases of emerging industries, key projects, research and development, public service platform and innovative capacity. Local financial authorities should also set up industrial development funds in reference to local priorities for the development of emerging strategic industries; the funds should be dedicated to basic research, R&D, technological innovation and research-into-use program of national level emerging strategic industries.

ii) Develop funds for start-ups and equity investment. Efforts should be made to encourage government to development funds for start-ups and equity investment through stock participation. China should set up a government piloting fund for investment in start-ups in emerging industries, scale up government investment in start-ups in emerging industries, guide and lead private investment into innovative enterprises in the early or middle stages of their pioneering undertakings in the emerging strategic industries. China should improve and implement relevant policies, and guide and encourage the private sector to make investment in emerging strategic industries. Efforts should be made to establish and improve supporting policy and supervision systems to promote the robust development of start-ups and equity investment, and create conditions for insurance companies, social security fund, corporate annuity administrative institutions and other institutional investors to participate in funds for start-ups and equity investment within the sphere of controlled risks.

iii) Improve tax incentive policies. While fully implementing all taxation policies to promote technological investment and research-into-use program, as well as supporting the development of high-tech industries, in reference to the direction of taxation reform and categories of tax, considering the high human capital and R&D expenses and the difficulty in commercialization at the early stage of product development, from the perspective of motivating proprietary innovation, guiding consumption and encouraging the development of new types of business, China should design and improve transfer tax, income tax and other supporting policies according to the specific feature of the industry, thus to shape policy means to mobilize private resources to develop emerging strategic industries.

iv) Improve financial policies. Financial institutions should intensify financing support to emerging strategic industries, including encourage financial institutions to innovate on mode of service, provide financial products and services suitable for emerging strategic industries, establish suitable credit management and loan variety systems; advance innovations of financial products such as intellectual property collateral financing, industrial chain financing etc, and develop new types of financial services; through establishing a multi-tier guarantee system encompassing fiscal funding and private funding, China should use government discount loans, risk compensations and other favorable policies to promote financial institutions to intensify support for the development of emerging strategic industries. Efforts should be made to give full play the role of the capital market to support the financing of emerging strategic industries, including the Growth Enterprise Market system and support eligible enterprises in the emerging strategic industries to list and finance; China should promote the development of over-the-counter market and satisfy demands of start-ups at different stages of development; bond market should also be developed to expand financing channels for enterprises in emerging strategic industries.

3. Developing a modern service industry

i) Set up a special fund for the development of modern service industry. A special fund for the development of modern service industry should be set up to provide subsidy and loan discount for key projects, support the development of modern service industry, especially finance, modern logistics, high-tech service industry, business service and other production type service sectors and promote the integration of production type service sector and advanced manufacturing industries. Fiscal subsidies, government discount loans and incentive policies should be used flexibly to guide private investment into technological and information services, to better exercise the leveraging effect of public finance.

ii) Improve the taxation system for the service industry. Given the fact that at the current stage, the service industry continue to follow the business tax system, efforts should be made to earnestly implement the favorable policies released by the government related to the business tax and income tax in the service industry and increase preferential treatments. Given the fact that service industry was incorporated into the expanded incidence of taxation of VAT, efforts should be made to appropriately identify the tax burdens for production type service sectors in association with the VAT reform and improve relevant taxation systems.

iii) Expand the scope of services and productions eligible for government procurement. Government procurement policy should be used appropriately. Except for goods and engineering projects, the procurement of service is also an important component of government procurement. For some modern service sectors, such as information service and energy-saving service that are within the scope of government procurement could directly use this approach to support their development.

iv) Improve other policies. Firstly, expand financing channels for enterprises in the service industry and support eligible enterprises to list and issue bonds; secondly, service sectors whose development are encouraged could enjoy the same prices of electricity, water, gas and heat as the secondary industry. Efforts should be made to expand land supply to the service industry and land returned by manufacturing enterprises should be used for the development of service industry on a preferred basis.

6.2.3 Innovation and application of low-carbon technology

Speed up the research and development as well as application of low-carbon technology and strengthen its innovation mechanism to boost the development of low-carbon Industrialization.

1. Propelling breakthroughs of low-carbon technology.

China should endeavour to understand the trend of low-carbon technology development and deploy relevant basic research and frontier technological research in advance so as to seize the commanding height of future technological competition, for example, trying to achieve breakthroughs in such fields as carbon capture & sequestration technology (CCS), alternative technology, minimization technology, recycling technology, reclamation technology, energy utilization technology, bio-technology, new material technology, green consumption technology and ecological restoration technology, etc., according to the development of low carbon Industrialization. In addition, China should also pay attention to the development of multi-industrial low carbon technologies including Internet of the Things, measuring technology and electrical machinery technology etc.

2. Public R&D institute and experimental platform.

China should accelerate the construction of research platforms for basic, frontier and generic technologies in the purpose of strengthening the capability of original innovation, integrative innovation as well as innovation based on introduction, digestion and absorption. Public R&D institute and experimental platform hold a very important position in the supporting system of technology innovation, especially for the research and development of structural and generic technologies, Industrialization promotion as well as implementation of major national research programs. In the energy field, it is suggested that an national low carbon energy research institute should be set up and opened, and such institute should not only possess general research conditions and facilities, but also should be able to conduct pilot plant test, so that it will be qualified for the whole research process, from basic research to technological development, experimental demonstration, detection and authentication. The institute is supposed to be open to enterprises, universities and other research institutes and is expected to solve the problem of insufficient supply capacity of generic technologies in low carbon energy industry with its performance of basic and generic technology research & development, experiment, testing and authentication, etc. At the same time, support should also be given to the construction of enterprise technology center, as well as that of technology development platform and technology innovation service platform for enterprises.

3. A technology innovation system centred on the private sector.

The establishment of a technology innovation system, which is dominated by enterprises, based on market and integrates industries, universities and research institutes as a whole, could be boosted by more technological resource support from the government, because government input will be able to attract and guide more capital input and innovative factors to enterprise from all circles of life. China should encourage large enterprises to increase R&D input, and at the same time stimulate the innovative vitality of small and medium-sized enterprises so as to give full play of enterprises in the aspects of R&D investment, technology innovation activities and innovation application. What’s more, China can adopt new forms of scientific research organizations to create stronger aspiration of innovation for research institutes and universities by funding and guiding the founding of an innovation strategic association comprised of enterprises, research institutes and universities, which allow entrepreneurs and leading scientific talents to play a key role in technology innovation. Government can either fund existing innovation association or build new industrial association with financial funds to realize breakthroughs in the localization of generic technologies and crucial components.

4. Industrialization of low carbon technology innovation.

The specific measures for doing so are as follows: firstly, continue with the implementation of self-reliance supporting project and the requirement for localization rate of major projects because they are especially crucial for promoting localization and independence; secondly, put the regulations of "Adjusting and Revitalizing Plan for Equipment Manufacturing Industry" into practice at the earliest, establish risk compensation mechanism for using the first domestic equipment, and encourage insurance company to start business targeting at the first important domestic technical equipment; thirdly, continue to use such fiscal measures as interest subsidy, assurance and premium, put the preferential tax policies into practice to encourage technology innovation, and adopt necessary financial policies such as intellectual property collateral financing; fourthly, support low carbon experimental demonstration, for instance, encouraging the consumption of new low carbon product, as well as the pilot and demonstration of CCS through fiscal and taxation policies (For more detailed fiscal and taxation policies and measures, please refer to the section of "Building a green fiscal and taxation policy system").

6.2.4 Improving the pricing system of energy and major resources

Conduct reform of energy pricing system to make it able flexibly to reflect market supply and demand, resource shortage and environment damage degree, so as to promote structural adjustment, resource conservation and environmental protection.

Reform should be carried out in the following areas: firstly, gradually realize market pricing in competitive energy fields and conduct supervision over natural monopolistic sectors according to clear regulations; secondly, allow the external cost and resource consumption of energy in the process of development, conversion and utility be fully reflected in the prices of energy products; thirdly, for cross subsidization, gradually turn "invisible subsidy" to "open subsidy" and the cross subsidization will finally be replaced by basic energy consumption subsidy supported by public finance.

There are detailed policies for different energy resources:

(1). Coal industry: according to the linkage mechanism of price, taxation, fee and rent, coal resource tax will follow the means of ad valorem to moderately raise taxation level. The cost accounting policy of coal needs to be reformed to cover various costs of coal resource subsidy, safety production, remediation and recovery of production environment, coal mine line changing and occupational health; in other words, let coal price covers all costs through the internalization of external costs.

(2). Power industry: promote electricity price reform; in the sector of feed-in tariff, the tariff of regular electricity sources such as thermal power should be decided by the market; direct electric power trade of big customer and bidding feed-in tariff pilot can be carried out; in the sector of power transmission and distribution price, an independent transmission and distribution pricing mechanism should be formed; as to electricity sales price, the assortment structure needs to be reformed to determine the relation between price parity and price difference reasonably, gradually solve the problem of cross subsidization and create condition for the implementation of bilateral power trade. Ladder-type electricity price policy can be adopted for residential electricity consumption. The electricity generation price and cost sharing mechanism of renewable energy sources should be improved. With the development of renewable and low carbon energy sources, the added level of renewable energy needs to be adjusted in time, and correspondingly increased costs should be fully divided.

(3). Oil and gas industry: further promote the price reform of refined oil products, and the government should optimize the forming mechanism of oil product price which is linked to international oil price to increase price flexibility. Looking from the medium and long term, market reform should be carried on actively to realize easy access of oil products, competitive market structure and market pricing. Cost price of gas should also be determined by market instead of government. At the same time, the price parity between gas and alternative energy should be made clear through adjustment of resource tax.

(4). Urban heat supply: besides advocate for central heating, China should encourage and support combined cooling-heat-power (CCHP) project, which is of higher energy efficiency. And China should also popularize the practice of individual heat/cooling metering system, advance heat charge reform and provide appropriate subsidy for those who purchase building heat metering and temperature control devices. Last but not least, finalize heat charge subsidy reform as soon as possible, changing "invisible subsidy" to "open subsidy", and form a heat charge policy of "more consumption more bill" to realize commercialization and monetization of heat supply and gradually establish a scientific and reasonable heat supply pricing mechanism.

6.2.5 Optimizing relevant market mechanisms (e.g. carbon trade)

Besides using carbon tax to determine carbon price, Chinacan also make full use of market mechanisms to reduce emission at lower cost, such as carbon trade, clean development and contract energy management mechanisms etc., along with other policies to advance the development of low carbon Industrialization.

1. Establishing a carbon emissions trading system

In the long term, it is necessary for China to establish a carbon emission trade system, which starts from a relatively closed system aiming at controlling greenhouse gas and targets at domestic carbon emission reduction. There is also international consideration, that is, to realize independent emission reduction goal by 2020 and get prepared for entering international carbon emission market.

i) Build a carbon emission trade system step by step. Owing to the complexity of this building process, it must be conducted in a planned and orderly way. China could try with volunteer emission reduction (VER) to accumulate experience and capability of technical methods and management. Appropriate subsidy or credit support could be provided to attract enterprises to reduce emission voluntarily. Those who participate in carbon emission reduction will put forward an emission proposal according to baseline emission, and then the government will organize these enterprises to participate in carbon emission trade. At the same time, this project must be combined with our 2020 per unit GDP carbon emission reduction goal, therefore, China could first consider the practice in appropriate and competent pilot area and industry, and gradually popularize it after sufficient exploring and experience accumulation. To start with, China can establish an emission right trading system with enterprises as its foundation in those pilot areas or cities, which is part of that area or some enterprises' carbon emission goal. As to pilot trading system and without proper quantization index of emission reduction, relative index such as carbon emission reduction intensity should be adopted instead of aggregative index; however, for some industries such as power industry and aircraft industry, aggregative index of emission reduction could be considered. For instance, China's aircraft industry is about to be included into EU carbon emission trading system, so Chinacould consider the usage of aggregative index to cope with this situation actively.

ii) Build carbon trading market and gradually establish the pricing system of carbon trade. The first thing to do is to set up a trading platform-carbon trading market, which can be realized on the basis of existing environmental exchange by learning from the experiences of international carbon trade systems. Currently, many places are racing on the building of carbon trade centers without deep understanding of carbon emission right trade, therefore, it must be regulated. At the same time, Chinacould also accept support from developed countries in the aspects of funds, technologies and capabilities to build emission reduction platform-carbon trading market, so as to realize effective joint of carbon trading market with voluntary emission reduction and clean development system. In the second place, carbon emission right trade should be localized according to China's national conditions and relative capacity building should be strengthened on the basis of pilot, which can be specified as follows: a) intensify capacity building of emission statistical and monitoring system, such as emission measurement, report and inspection, to realize on-line monitoring; b) encourage domestic financing service industry to play an important role and regulate commercialized carbon trade behavior to create a transparent, open and fair market environment; c) provide training program for relevant staff engaged in carbon emission right trade to familiarize them with domestic carbon emission right trade regulations and pilot application and to be competent for their job. In the end, intensify policy support for carbon emission right trade such as financial subsidy, cost allowance and tax preference etc.

iii) Coordinate the relation between carbon emission trading system and carbon tax. The relation between the two is not simply substitution, but complement. When collecting carbon tax in the future, the operation of carbon emission trading system and carbon taxation system should be coordinated. This is actually an application of EU practice, allowing energy intensive enterprises to choose carbon emission trading system, for instance, if they do not reach the goal, they can purchase carbon emission in carbon trading system instead of paying carbon tax.

2. Utilizing the current clean development mechanism (CDM)

Within current global emission framework, CDM should be made full use of, not only for winning international emission reduction fund, but more importantly, for achieving transfer and diffusion of energy saving and emission reduction technologies. With changing domestic and international environment for CDM program development, China's CDM program development will be affected by future trend of international carbon market as well as by the relation between CDM and 2020 individual emission reduction goal. Development of CDM program should be continually encouraged and domestic management policies should be adjusted appropriately to cope with new international and domestic situation and further boost energy saving and emission reduction.

Specific measures include: a) speed up CDM program development with deep understanding of the timeliness of greenhouse gas emission reduction potential; b) identify CDM contribution for emission reduction with encouragement for domestic enterprises to continually develop CDM programs and include it into China's independent emission reduction goal; c) adjust China's CDM program price management system and establish effective coping mechanism in order to adapt to new international situation; maintain preferential taxation policy to advance CDM program development, facilitate potential emission reduction technological capability through CDM and make full use of CDM fund.

3. Optimizing market mechanisms for energy saving and low carbon development

i) Promote the practice of contract energy management. As a new mechanism which facilitates energy saving through market method, contract energy management is a widely used in developed countries. It should also be widely promoted in China with combination of China's energy saving service industry. Current treasury supporting policies related to contract energy management should be further intensified and adoption of contract energy management system should be encouraged among energy saving service enterprises.

ii) Encourage enterprises to sign energy saving agreement voluntarily. Voluntary agreement is the most widely used non-obligatory energy saving measure. Chinacould encourage enterprises to sign this kind of voluntary agreement with several measures including financial subsidy, premium, interest subsidy, tax preference and trade mechanism, etc. to activate their initiative. Highly energy consuming industries can set higher energy saving goals so as to advance energy saving and energy efficiency of the whole industry as well as the whole nation, and finally improve the quality and efficiency of economic development.

6.2.6 Building a green finance and tax system

Table 6-1: Green Fiscal Policies

Support for energy conservation	Support for low carbon energy deployment	Support for low carbon technology R&D
Establish a national 'special fund for energy conservation'	Increase the size of the 'development fund for renewable energy'	At least 5% of public R&D expenditure should be focused on basic and applied low-carbon technology
Reductions in the corporate tax rate for energy-saving and environmental-friendly projects	Wider use of concessional loans and new advice for banks on their loan policies for renewable energy	Tax benefits for enterprises to offset their R&D investments
Subsidy for high energy efficiency consumer products	Subsidies for solar power and small-scale wind power for homes	Government support for large scale industrial pilots
Enlarge the range and proportion of energy-saving products purchased by the government including energy service agreements	Reduce import tariffs and value added tax on renewable energy technology and equipment	Harmonise financial support policies of energy conservation R&D and deployment.

Besides the financial and tax policies to support structural changes of strategic emerging industries and service industries such as enhancement in financial expenditures on energy saving and emission reduction, building of a green tax system, achievement of overall financial transformation, construction of a long-term system to promote low-carbon Industrialization and strengthened support from financial and tax policies for the development of low-carbon Industrialization, other financial and tax policies in favor of the development of low-carbon Industrialization include:

1. Finance and tax support for energy saving

ii) Enhance financial investment in energy saving. First, with the growth in overall financial capabilities in China, part of the increased financial revenue for the year should be invested in energy saving and capital investment in energy saving should be increased by adjusting the financial expenditure structure, condensing or reducing other expenses. Second, various existing financial investment in energy saving should be mobilized, including scientific and technological R&D investment related to energy saving and various governmental fund in the sector of energy saving such as investment within the budget of the central government, financial incentives for energy saving technological reformation, special fund for elimination of backward production capacity, special fund for office building of central governmental departments and large-scale public buildings and financial subsidies for the promotion of energy efficient lighting products. National special fund for energy saving should be set up so as to form a standardized and stable investment channel for energy saving and specify the leading role of governmental financial investment in promoting social energy saving. A central-to-local special fund for energy saving should be established. Main focuses should be given to high energy-consuming provinces and energy-saving provinces in mid and west China, local governments should arrange corresponding capital and the special fund should be applied to energy saving so as to better support the development of industrial energy saving.

ii) Improve existing financial subsidy policies related to energy saving and low-carbon products further. First, based on the requirements of various sectors of low-carbon Industrialization, take into consideration the characteristics of various financial policies, adjust and improve the national financial subsidy policies for energy saving, make full use of the financial budgetary investment, set up funds, subsidy, incentives, interest subsidy and guarantee and establish various financial subsidy policies such as investment subsidy, production subsidy, consumer subsidy, etc.. Second, scientifically design the financial subsidy and amount of subsidy. Applicable financial subsidy for various links should be specified and pertinence of the policies enhanced. Financial investment, including the investment in production and subsidy support in consumption in energy saving, needs to be increased. To be more specific, in terms of production, subsidy should be provided for technological reformation and the investment subsidy should be combined with the operation conditions of the energy-saving and emission-reduction enterprises so as to encourage the enterprises to further improve their technologies and lower down energy consumption. In terms of consumption, subsidy should be provided for consumer products such as energy saving lamps. Third, strengthen the implementation of subsidy policies on energy-saving products. Subsidy measures should be further improved to strengthen supervision on the implementation of policies and enhance operability and effectiveness of the subsidy policies, including enhancement of supervision on distribution and utilization of subsidy capitals to ensure the timely and adequate payment of subsidy capitals; improvement of information management system to form a tracing mechanism of product promotion information; strengthening of efforts in performance supervision spot-check and promotion information check and severe punishment on behaviors against the subsidy regulations so as to bring into full play the effective impact of the financial subsidy capital.

iii) Improve the tax policy on energy saving. First, based on the current tax preferential policies for energy-saving enterprises, corresponding measures should be adopted soon for existing preferential policies, such as the “three years’ exemption and three years’ half” preferential policies of the corporate tax on energy-saving and environmental-friendly projects; appropriate expansion on the range of preferential policies. For example, refer to the business income tax preferential policies of resources comprehensive utilization and grant certain preferential policies for the enterprises producing and manufacturing energy-saving equipment and products. Second, implement tax policies encouraging the promotion of energy-saving and low-carbon products. While implementing subsidy policies, tax policies can also be adopted to better enhance the effectiveness on the promotion of energy-saving and low-carbon products. In terms of tax policies, consumption tax can be collected on high energy-consuming products such as filament lamps and household appliances with high energy consumption to narrow the price gap between products with low energy consumption and those with high energy consumption and better promote energy-saving products.

iv) Improve the government procurement system for energy-saving products (low-carbon products) and services. First, enlarge the range and proportion of energy-saving products purchased by the governments. In order to strengthen the effectiveness of government purchase, it’s necessary to enlarge the range of energy-saving products purchased by the governments, choose products with a big social demand and obvious returns of energy saving from those certified energy-saving products and incorporate them into government purchase, improve the government purchase list of energy-saving products, enlarge the proportion of energy-saving products among the overall products purchased by governments, bring into full play the policy leading role of government purchase and promote the social production and utilization of energy-saving products. Second, improve the purchasing model of energy-saving products. China should continue to strengthen the certification of energy-saving products, timely adjust the compulsory government purchase list of energy-saving products and conduct compulsory purchase on some products with obvious energy-saving effect and relatively good performance. Meanwhile, since China has applied to join the Government Purchase Agreement, in order to avoid the potential prejudice and unfairness problems in the government purchase list, Chinacan consider the introduction of “standardized approach” or other government purchase models. Third, incorporate the energy-saving service under the energy management contract into government purchase. Energy-saving services should be clearly included in the range and content of government purchase and governmental agencies should be allowed to purchase from energy-saving service providers. As a result, the Energy Conservation Law of the People's Republic of China needs to be revised and the purchase of energy-saving services by “public facilities energy saving” be specified instead of only subject to products and equipments; at the same time, Chinacan start with the central level, actively implement energy-saving reformation on contracted energy management, choose some areas as pilots for government purchase of energy-saving products and then expand to the other areas across China when the conditions required are in place.

2. Finance and tax support for low carbon energy development

i) Improve financial and tax policies on renewable energy. First, implement the development fund for renewable energy as soon as possible. According to the revised Law on Renewable Energy, a development fund is required to be built by central finance to support the development of renewable energy. Management methods of development fund for renewable energy should be adopted and implemented as soon as possible, increase the investment of financial capital, enlarge the size of development fund for renewable energy, further specify function of the fund and build a better capital guarantee system for renewable energy, so as to ensure the sound and rapid growth of the renewable energy industries. Second, adjust and improve the financial subsidy policy in the renewable energy sector. Based on the existing financial subsidy policy in the renewable energy sector and in accordance with the development of various renewable energy, target group, relevant standards and conditions of the subsidy should be further specified; strengthen support for financial interest subsidy, guide banks to adjust their loan policies, enlarge loan size for renewable energy, allow preferential interest loans granted to renewable energy sector and expand financing channels for renewable energy; adopt new subsidy policy, including subsidies for solar roof building of households and small-scale wind power. Third, improve transfer payment and ecological compensation mechanism which promote the coordinated development of renewable energy, encourage trade of renewable energy between provinces and regions and bring into full play the incentive and constraint role of the market mechanism. China should consider the overall life cycle, whole industrial chain and whole interest chain, design supportive policies of finance, tax and government purchase and strengthen coordination among the policies. Fourth, further lower the value added tax on renewable energy sector, adopt income tax preferential policies and cut down the import tariff and value added tax on renewable energy equipment.

ii) Improve financial and tax policies supporting the development of clean coal. China should support demonstration of clean coal technology, support the Industrialization of clean coal, provide guidance for market force to invest in clean coal technology sector and mobilize enterprises to master and promote clean coal technology with a market-based orientation through financial, price subsidy, government purchase and preferential tax policies. For consumption and absorption of key introduced technologies and imported equipment and technology required by demonstration projects, besides preferential policies in import tariff and added value tax for import, financing support should also be provided; as for commercialized clean coal technology projects, low-interest loans or financial interest discount should be provided. China should include clean coal technology into national key technological reformation projects and have access to special loans for energy saving and loans for enterprise technological innovation.

iii) Adopt financial policies supporting the development of nuclear power. First, support the adoption and certification of nuclear power standards through financial subsidies. Active guidance should be given for market force to invest in low carbon sector such as nuclear power through guarantee, interest discount and other financial policies. Second, to implement financial interest discount and subsidy policies, pay attention to the matching and pertinence of financial, tax, finance and price policies at various stages, speed up the development of nuclear power R&D, project design, operation maintenance, education and training, building and installation and other nuclear power service industries, enhance and promote the development of nuclear power equipment manufacturing enterprises and focus on introducing and fostering nuclear power heavy equipment enterprises. Third, improve tax policies on key nuclear power materials, parts, equipment import and nuclear power supply, exempt import tariff, exempt or reduce the import added value tax and lower down the cost of nuclear power. At the same time, China should enhance financial and tax support for equipment local production and self-innovation, strengthen the advantages and competitiveness of nuclear power and promote the development of nuclear power.

iv) The external costs of energy development, conversion and utilization should be fully reflected in the prices of energy products; for example, the principle of making all costs visible applies to nuclear power (from the costs of nuclear accidents to decommissioning and waste management) as well as the coal industry and renewables sector.

3. Finance and tax support for innovation and application of low-carbon science and technology

i). Increase R&D budget for low-carbon technologies. While ensuring the steady increase of the financial and science and technological expenditure, China should raise its budget in the R&D of low-carbon technologies and gradually increase the proportion of low-carbon technological investment in the investment within the budget. The financial policy should mainly support the key and generic technologies of low carbon, especially the R&D of the advanced low-carbon technologies across the world, to boost the leapfrog development of low-carbon technologies. For example, it should be identified that in the R&D fund invested in the national finance, more than 5% will be used for the R&D of the fundamental and applicable low-carbon technologies.

ii). Provide tax incentives to the enterprises for their R&D and technological innovation. First, including the technical service revenue from the low-carbon technology transfer, training and consultation into the revenue that can enjoy the preferences of the technology transfer of enterprise income tax. Second, implement the tax incentive policies that can promote the technological progress such as the offsetting their taxable income with R&D expenses to improve the relevant supporting implementation so as to support their R&D and technological innovation.

iii). Encourage the demonstration and expansion of low-carbon technologies. Financial and taxation policies should prioritize the major and demonstration projects that can conserve energy and reduce emission. The key energy conservative projects such as replacing oil with alternative energy resources, cogeneration, residual heat utilization and energy conservation in buildings should be implemented to expand the investment in the technological transformation and update the traditional industries and backward technologies; in terms of industries, financial and taxation policies should mainly support R&D and expansion of energy conservation and emission reduction technologies in highly energy consumption industries such as steel industry, nonferrous metal industry, coal industry, power industry, petroleum and petrochemical industry, chemical industry and industry of building materials. Necessary fund in the government budget should be arranged to support and lead the expansion and application of energy efficiency technologies and industrial experiment expansion and discuss the possibility of establishing and improving a long term investment mechanism to promote the low-carbon Industrialization. Besides supporting large-sized enterprises, financial policies should vary to lead and support the expansion and application of various low-carbon technologies with business value among small and medium -sized enterprises based on their characteristics.

iv) In order to avoid the negative impact of policies due to the current low-carbon technology R&D, Industrialization and the separation of expansion and application departments, the coordination of financial support policies of energy conservation technology R&D, Industrialization and expansion and application should be strengthened to enhance the investment efficiency of energy conservation financial fund.

4. Supporting low-carbon transportation and construction

i). Support the urban public transportation with low energy consumption and low carbon emission. First, increase the financial investment in the development of urban public transportation system and accelerate the development of urban rail transportation and inter-city high-speed railway to form a diversified urban public transportation system. To develop the public transportation centering on the rail transportation may not only reduce the direct energy consumption but also helps to optimize the city functions and layout. Second, formulate attractive policy of low-priced public transportation with financial subsidies and raise car parking fee to encourage the healthy way of travel such as bicycles, urban railway (light trail and subway) and buses, etc. by using energy and transport resources efficiently and reducing the emission.

ii). Improve the financial and taxation policies and measures to encourage the energy conservation in buildings. First, offer more subsidies for green buildings in various ways and encourage the development and utilization of green buildings with financial fund. Second, provide initiation financial fund from stable sources and gradually expand the financial investment in the energy conservation renovation of the public buildings to encourage energy conservation renovation of buildings with high energy consumption and renovation of current public buildings by energy service companies. Third, consider the possibility of offering tax incentives for properties and urban land using.

iii). Perfect the financial support policies to improve the urban energy supply ways. First, increase financial investment and allocate a certain proportion of fund for cogeneration and central heating; second, provide some financial subsidies to the heat supplying enterprises.

5. Imposing carbon tax at an appropriate time to signify a stable price for low-carbon technology innovation and its large-scale application

Imposing carbon tax at an appropriate time may signify a stable price for low-carbon technology innovation and its large-scale application to reduce CO2 emission, help China shoulder its due responsibilities as a developing nation in terms of several environment problems such as greenhouse gas emission reduction in the world and decrease the emission of SO2, NOX and other pollutants. Therefore, imposing carbon tax based on China's national situation is very necessary.

i). Ways of imposing carbon tax. Imposing carbon tax is closely related to the other relevant taxes of energy. When carbon tax was not imposed on the emission amount, then carbon tax, resource tax and consumption tax would be imposed on similar fossil fuels such as coal, natural gas, gasoline and diesel. Due to such a similarity, there are many options for the ways of imposing carbon tax: first, based on the current resource tax and consumption tax, the carbon content in fossil fuels can be the foundation for tax imposition; second, impose carbon tax besides consumption tax and environment tax; third, regard imposing carbon tax as an item of environment tax. In line with the tax reform principle of "broadening tax base and simplifying tax system", based on the development of environment tax in China, it is suggested that the third way of imposing carbon tax should be adopted. When optimizing the environment taxation system and integrating tax categories imposed on fossil fuels in the future, China may consider the possibility of changing the tax categories imposed on fossil fuels into carbon tax.

ii). Choosing between carbon tax and carbon emission right transaction. As compared with carbon emission right transaction, carbon tax has obvious advantages in terms of basic conditions for system development and operation environment: first, carbon emission right transaction needs to identify the total amount of carbon emission and allocate carbon emission rights. This transaction concerns interests of various parties and is difficult to implement before an agreement. And it also has put a high demand on market environment and basic conditions. But carbon tax is more flexible; second, carbon tax conforms to the "polluters pay" principle while carbon emission right transaction allows enterprises with more carbon emission right quota to sell their rights when the emission amount is falling. So carbon tax is fairer and more transparent; third, due to the high cost, carbon emission right transaction is often limited to major energy consumers such as power generation industry while carbon tax is applicable to all CO_2 emitters; fourth, government can earn revenue with carbon tax which can be used for energy conservation and emission reduction.

The disadvantages of carbon tax are as follows: first, due to the impact of price elasticity of demand, the emission reduction of carbon tax is not as effective as the carbon emission right transaction; second, there is a great pressure from enterprises. Enterprises often prefer carbon emission right trade because if they adopt free allocation system of primary emission rights, then it means they can get some emission amount without tax; in addition, as for the enterprises with a large carbon emission, if they can reduce carbon emission, then their emission rights can be sold. On the whole, carbon tax and carbon emission right transaction are both important means to promote the economic policies of carbon emission reduction. Based on China's national situation, carbon tax system may be more possible to realize the objective of voluntary emission reduction effectively; carbon emission right transaction can be an objective for long term system development in line with the market conditions.

iii). The tax rate of carbon tax. While China is developing rapidly in both society and economy, carbon tax will have a great impact on some high energy-consuming industries and industries with a high energy cost. In order to stimulate the CO_2 emission by tax payers and prevent the adverse impact of carbon tax on the international competitiveness of Chinese industries and the living standard of the low income group, carbon tax should start from a low tax rate: selecting low tax rate and tax rate with a limited negative impact on the economy (e.g. RMB 10 per ton of CO_2) in a short term and then raise the tax rate with the improvement of economic development and the bearing capacity of society. Meanwhile, it is also necessary to establish a dynamic adjustment mechanism of carbon tax incidence (including the forecast of raising the tax rate) based on the actual development of China's economy and society and the demand for international coordination so that the carbon tax can play an important role in urging enterprises to voluntarily reduce emission.

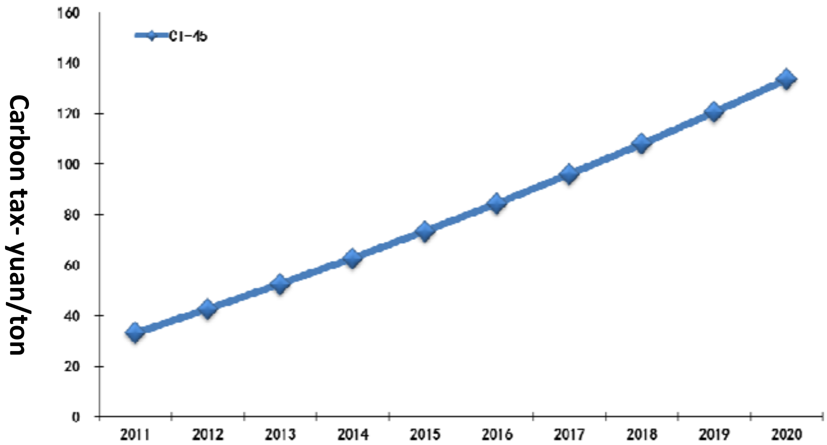
Box 6-1: Calculation of carbon tax level based on the model

The model mainly studies carbon tax scenario with cascade tax rate adopted during the 12th Five-Year Plan and the 13th Five-Year Plan under constraint of a 45% reduction of carbon intensity of economic sector relative to 2005, and identify carbon price level of carbon intensity target.

With a 45% reduction of carbon intensity, carbon price level of industrial sector is shown in the Figure. If cascade tax rate is adopted, the carbon tax level is about 75 yuan/ton in 2015 and 135 yuan ton in 2020.

Figure 6-2 - Carbon price level during the 12th Five-Year Plan and the 13th Five-Year Plan, with a 45% reduction target of carbon intensity

Table 6-2: Primary Design of CO_2 Tax Rate [1]



Tax rate	2012	2020
Carbon tax (RMB per ton of CO_2	10	40
Raw coal carbon tax (RMB per ton)	19.4	77.6
Crude oil (RMB per ton)	30.3	121.2
Gasoline carbon tax (RMB per ton)	29.5	118
Diesel carbon tax (RMB per ton)	31.3	125.2
Natural gas carbon tax (RMB per 1000 cubic meter)	22	88

Note: 1) Hypothetically, impose carbon tax in 2012; 2) The formula among carbon tax rate, coal tax rate, oil tax rate and natural gas tax rate is as follows: RMB 1 per ton of CO_2=RMB 1.94 per ton of coal=RMB 3.03 per ton of crude oil=RMB 2.95 per ton of crude oil=RMB 3.13 per ton of crude oil=RMB 2.2 per 1000 cubic meters of natural gas.

iv). Carbon tax incentives. In order to prevent great negative impact on the international competitiveness of China's industries and reduce the resistance of carbon tax imposition, China should consider the possibility of designing a package of supporting policies and measures relevant to tax incentives and conducive to industrial transformation. First, in order to protect the international competitiveness of China's industries, China may establish rational tax revenue reduction and exemption and rebate mechanism in the energy intensive industries. But these industries must sign energy conservation and emission reduction agreement of certain standards with the Chinese government and make promises. Second, tax reduction and exemption should be offered to enterprises that has reduced emission with technologies and reached a certain standard.

v) Utilization of carbon tax revenue. Two options for utilizing carbon tax revenue exist, namely earmarking and budget management. In terms of strengthening China's financial management, carbon tax like other tax categories should be included in the united budget management to ensure the normative financial management. Meanwhile, if earmarking is not adopted, it doesn't mean that financial investment in low-carbon economic development, energy conservation and emission reduction lacks guarantee. But carbon tax as a tax category with a specific purpose is closely related to climate change combat and low-carbon economic development. In terms of the demand of fund to ensure energy conservation and emission reduction and low-carbon economic development, China may consider the possibility of earmarking to identify that the carbon tax revenue is used for sustainable development.

Table 6-3: Elements of the carbon tax system

Elements of tax system	Basic regulations
Tax payer	Organizations and individuals who directly emit CO2 to the natural environment due to consumption of fossil fuels.
The range and objective of taxation	Those CO_2 emissions discharged by fossil fuel consumption in production, operation and daily life into natural environment. In the long term, the CO_2 caused by individuals using fossil fuel in daily life should also be included in the taxation objectives; but recently, the CO_2 from family is also temporarily exempted from taxation, except for those caused by individuals using finished oil such as gasoline and diesel.
Tax calculation basis	Estimate emission amount, based on the fossil fuel consumption of tax payer. CO_2 *emission=fossil fuel consumption × emission factor* Fossil fuel consumption level refers to the volume of fossil fuels consumed in companies' production and operation to emit CO2, including coal, natural gas, gasoline, diesel and etc, which are calculated according to companies' account record; the emission factor is determined by the types of fossil fuel and related parameters.
Tax rate	It will be fixed rate according to the amounts. In the initial implementation of a carbon tax, it can take low tax rate as a starting level, like RMB 10 / ton of CO_2 Conversion of carbon tax rate: RMB 1 per ton of CO_2=RMB 1.94 per ton

	of coal=RMB 3.03 per ton of crude oil=RMB 2.95 per ton of crude oil=RMB 3.13 per ton of crude oil=RMB 2.2 per 1000 cubic meters of natural gas.
Taxation stage	The taxation will be designed to be charged in the consumption stage of fossil fuel. But according to the real situation of taxation management, in the initial implementation of a carbon tax, the tax on coal, natural gas and finished oil will be charged during the exploit and production of fossil fuel energies; in the future when taxation management situation permits, the tax on finished oil and natural gas could be charged in the process of whole sales and retail, and tax for coal could be charged in consumption of energy intensive enterprises.
Tax preference	**Tax incentives :** (1). In the initial implementation of carbon tax, define the what kind of industries can enjoy the preferences according to the demands of the national macroeconomic policy and economic restructuring, and offer those energy intensive industries which have large influences (some pillar industries according to China's relevant industrial policies and macro economy) certain tax exemption in a certain period (2). Offer tax exemption to those enterprise which actively use technologies to reduce and recycle CO_2 and reach certain standards.
Other elements of tax system	The regulations on tax deadline, tax payment place and other system elements□omitted□
Tax revenue attribution	It is suggested that carbon tax revenue be shared by central government and local government, with sharing proportion of 7:3.
The use of tax revenue	Take carbon tax revenue into budget management. Meanwhile, increase the fiscal investment on energy saving, environment protection and climate change debate.

6. Fiscal reform

i). The tax adjustment in the exploitation of resources will make resource prices reflected in energy prices. At present, our country's resource tax reform have take place in oil and gas resource tax system in western areas to calculate tax according to price. China should increase resource tax rate appropriately according to the linkage mechanism of price, tax, fee, and rent to improve the tax charging methods, change the calculation of fixed tax on those important resources such as coal from according to quantities to prices as soon as possible, and carry out reforms all over the country. Make sure the resource tax system is designed to reflect the specialty of resources and demand of resource conservation, in order to advance the reasonable exploit and utilization of natural resources.

ii). At the energy consumption stage, levying energy tax will guide energy consumption behavior and using methods by increasing cost of energy using. There are two parts in the adjustment of consumption tax policy: one is to appropriately increase the tax rate of high energy-consuming products like existing finished oil and large displacement vehicles. Since the implementation of fuel tax reform, our country's finished oil tax rate has already been increased. Now China should increase the consumption tax rate of finished oil according to other energy tax reform. The other one is to widen the tax range, to cover high energy-consuming products, resource-consuming products which are not the taxation objectives and do not meet the technical standards for energy conservation.

iii). Implement environment tax reform actively. Recently China should improve the charging system of pollutant discharges and increase the collection rate of pollutant discharges fee. At the same time, on the basis of existing charging system of pollutant discharges, levy environment tax (or pollutant discharges tax) on those pollutants like waste gas, waste water, waste solid materials which are the main control tasks with mature technical standards, and increase the environment tax appropriately, so that the environmental damage cost will be reflected in the prices of energy products and other products.

iv). Continue to improve other energy tax policies. Firstly, under present circumstances the existing vehicle and vessel tax are charged according to the emission volume, and the tax of large displacement of the passenger cars is increased, China should improve motor vehicle tax policy combining with other tax charges taken in other aspects of motor vehicles, so as to promote energy saving and emission reduction in motor vehicle. Secondly, continue to maintain existing tax policy restricting exports of high energy-consuming products, including canceling and lowering export tax refund rate, as well as levying export tax on some high energy-consuming products. Under the premise not to affect the export and economic development, China should also widen the effective scope of these policies and decrease the energy export in form of energy carrier.

6.2.7 Increasing financial support

Put carbon-finance development into the policy framework of national climate change and low-carbon economy development, making the carbon finance the main policy tool to promote low-carbon Industrialization.

1. Green credit policy and policy support for carbon emission reduction.

On the basis of existing green credit policies supporting energy conservation and emission reduction programs, combined with China's carbon emission reduction targets, China should give preferential treatment on credit for carbon emission reduction projects, support the low-carbon enterprises and related programs in priority, which will ease the bottleneck of resources, control environmental pollution and reduce green house gas emission.

Greatly promote carbon-right secured loan and provide financial support for CDM projects; actively develop credit-guaranteed financing and offer preferences in loan audit, loan release, repayment deadline, loan interest rate for key low carbon economy development projects. Besides, establish special loan for the purchaser in the emission right trade.

2. Low-carbon capital markets.

In the area of capital market financing, China should support those enterprises in priority which are devoted to development of low carbon technologies and low carbon economy to get listed on GEM, and promote small and medium sized enterprises developing low carbon economy to be listed; verify proposals from qualified low carbon enterprises or developing projects on issuing corporate bonds, company bonds , short-term financing bills and other debt financing instruments to get money for development in priority; actively support financial institutions to issue the "low-carbon bonds" to get money invested in some long-term and large-sized low carbon industries; enhance the training and development of low-carbon trust fund and encourage private equity funds, venture capital, social capital and international aid donations to increase investment in low carbon and emission reduction projects.

3. Innovation in carbon finance products

According to the development of our country's carbon emission right trade market, through cooperation with banks, insurance institutions and investment institutions, China should accelerate the development of financial derivatives and products including carbon swap, options and futures which support the low carbon economy to enrich the market, satisfy various investors' requirements of hedging and avoiding risks, and promote the rapid growth in low carbon financing and low carbon economy. Besides, China can also gradually establish carbon bank system to set up carbon account for different areas and important enterprises, and discover future price of carbon.

4. Policy support for carbon finance

Announce laws and regulations related to carbon finance as soon as possible and improve the carbon trading law and supervision framework. Establish and perfect the climate change database and carbon risk evaluation criteria to create a friendly policy environment for stable development of carbon finance. Meanwhile, provide supportive policies on finance and taxation for financial institutions' earning from carbon finance business. In aspect of policy support, China should use financial allocation to establish special fund, providing interest subsidy for CDM projects.

6.2.8 System of laws, regulations and standards

Improve the laws, regulations and standards related to low carbon economy and ensure that they are enforced, so as to better promote the development of low-carbon Industrialization.

1. Laws and regulations promoting carbon emission reduction.

Strengthen the establishment of the legislation of responding to climate change and list it in the lawmaking agenda, lay down the Law on Responding to Climate Change according to China's particular situation, properly modify and perfect the laws related to climate change and environmental protection, and timely announce the supporting laws and regulations. Formulate, promulgate and implement Law on Energy as soon as possible and revise Law on Coal, Electric Power Law, Law on Energy Conservation, Renewable Energy Law, and other laws and regulations accordingly, so as to encourage the exploitation and utilization of low-carbon energy.

Draw up the relevant supporting regulations of Circular Economy Promotion Law to promote the development of circular economy. Based on Agriculture Law, Forest Law, Grassland law, Land Administration Law, and other relevant laws, establish and complete the system of laws and regulations which not only accord with administrative laws and regulations but also can improve the productivity of agriculture and forestry and increase carbon storage in the ecosystem of agriculture and forestry; revise the plans to protect and construct forest, farmland, and grassland, forbid to cultivate the land in the region with poor ecosystem, and refuse to destroy wildwood, grassland, and cultivated land for any reason.

The key regulatory proposals are:

Table 6-4: Key Regulatory Measures

1. Introduce a “Top Runner” program for key industrial equipment and energy-consuming products
2. Strengthen energy-efficiency standards for industrial equipment with high energy consumption such as draught fans, water pumps, voltage transformers, and motors.
3. Review and potentially tighten efficiency standards for major energy-consuming products such as household appliances, lighting fixtures, office equipment, and motor vehicles
4. Introduce energy efficiency labels and certification across a wide range of energy-saving products, based on a new standards carbon footprinting methodology
5. Revise standards for the energy efficiency of buildings
6. Establish standards for temperature control (heating and cooling) in buildings
7. Assess and review energy efficiency standards for fixed asset investment projects

2. Developing standards for energy efficiency and low-carbon products.

Perfect the design specifications of energy conservation and the standards of building energy efficiency for major energy-consuming industries and complete the standards to control temperature for heating and cooling of buildings; revise energy-efficiency standards and control energy-consumption limit of major industrial equipments with high energy consumption such as draught fan, water pump, voltage transformer, and electromotor and major energy-consuming products such as household appliance, lighting fixture, office equipment, and motor vehicle. When revise the standards of energy efficiency or emission, China can consider adopting the method of “Top Runner” by Japan, that is, the level of energy efficiency or emission of enterprises with best performance in the last term will serve as the standards of the next term.

In addition, China should also set a full energy efficiency label and perfect the certification of energy-saving products, so as to expend the application scope of Mandate Energy Efficiency Labelling System. Develop the system of “carbon footprint” labelling and low-carbon product certification, carry out the system of “carbon footprint” labelling in turn, extend the use of labelling, increase social recognition, guide the consuming behavior and change it into low-carbon mode, and allow enterprises to speed up the development and research of low emission products.

3. Implementing energy efficiency standards

As for industrial projects, consider fully the assessment and review of energy efficiency standards and fixed asset investment projects. Assess and review the level of carbon emission reduction for new, remodeled, and expended fixed asset investment projects, refrain from examining and approving projects without ,or not passing, the procedure of emission reduction review, thus reducing carbon emission from the source. As for construction projects, once large-scale public buildings and commercial residential buildings have been established, they should accept the special assessment of energy efficiency in buildings, and the completion procedure will not be transacted if the above buildings can not reach the mandatory standards. In addition, China will further establish the system of monitoring, index and evaluation of energy saving and emission reduction, strengthen the responsibility assessment for energy-efficiency goals, and perfect system of rewards and penalties.

4. Sectoral targets for energy-intensive industries

Over the past five years China has focused on regional targets for energy intensity and action by local government. Moving forward, some policy challenges, such as standards and technology platforms for innovation, can only be tackled effectively at national and sectoral level.

Energy-intensity targets should be introduced for seven heavy industry sectors: electricity, steel, building materials, petrochemicals, non-ferrous metals, textiles and paper and pulp. Potential energy-intensity targets are displayed in Table 6-5. These are based on detailed analysis by the Task Force, taking into account the experience of China's industry during the 11th Five Year Plan period and assessments of the technical and practical potential to upgrade each sector. Extensive discussions were conducted by the Task Force, with industry bodies as well as academic experts.

Table 6-5: Selected energy intensity improvement potentials for heavy industries

	Energy intensity in 2005	Decline by 2015 (%)	Decline by 2020 (%)
Electricity Thermal efficiency of electricity generation (gce/kWh)	370	13.5	16.2
Steel			
Crude steel kgce/t	741	12.3	15.3
Petrochemicals			
Ethene kgce/t	1081	11.5	14.5
Synthesis ammonia kgce/t	1774	12	17
Caustic soda kgce/t	1351	20.9	25.7
Soda ash kgce/t	530	20.9	25.7
Calcium carbide kgce/t	2095	15.5	19.5
Building materials			
Cement kgce/t	149.2	27.3	31.3
Non-ferrous metals			
Electrolytic aluminium kWh/t	14575	6.2	15.2

Textiles			
Chemical fibers kgce/t	743	18.4	23.3
Paper-making			
Paper and paperboard kgce/t	525	25.7	31.4

6.2.9 International cooperation

More international cooperation in the field of low carbon in terms of technology, capital, management, etc is also an important measure to promote low-carbon Industrialization.

1. More cooperation with developed countries on low-carbon technology.

Cooperate with other countries to develop the partnership, international cooperative patterns, and institutional innovation, create an international platform for technical exchange and cooperation, increase scientific and technological level and innovation ability at home by collaborative research, rational technology transfer, and other ways, narrow the gap with the developed countries in advanced low-carbon technology, and enhance the ability of independent innovation, so as to make a breakthrough in terms of law-carbon technology and gain a competitive advantage in the global carbon emission market.

2. New system in international cooperation.

Through new system applied in the international cooperation of climate change, strengthen international communication and strategic policy dialogue in climate change, carry out the pragmatic cooperation in scientific research, R&D of technology, capacity building and other aspects, push forward the construction of international cooperation platform and management system for capital and technology transfer, urge developed countries to follow their commitment in terms of financial support and technology transfer, introduce, understand and absorb advanced and applicable low-carbon technology, set the international standards and benchmark of industrial energy efficiency and carbon intensity together, and enhance the level of low-carbon technology, equipments, and products in China’s major industries and sectors.

3. Cooperation in other areas

In addition to international technology exchange and cooperation, China should improve the ability to provide personnel training and professional training in clean development mechanism, strengthen the partnership among developed countries, international organizations, research institutes, enterprises, NGOs, and associations, and organize the cooperative activities such as academic research on the development of low-carbon economy, experience sharing, and capacity building etc.

6.2.10 Strengthen talent training and construction

To promote the development of low carbon Industrialization needs lots of middle- and high-end talent in low carbon scientific research, management and finance. To strengthen talent training and construction in low-carbon economy is a systematic solution to the development of low carbon Industrialization.

1. Talent-training in low carbon areas.

Based on talent demand in low carbon area, support low-carbon research projects and discipline construction of colleges and universities, establish talent training bases, build effective mechanisms with enterprises as the subject as well as close cooperation among industries, universities and research institutes and vigorously strengthen the development of all kinds of technical talents in low carbon area; strengthen publicity and professional training of enterprises and governments in low carbon area and widen talent training channels; establish effective mechanism for talent motivation and competition and create good external environment in favor of talent training; improve construction and integration of talent forces and form talent forces in low carbon science and technology R&D and management with strong independent innovation ability, outstanding professional skills and international influence.

2. High-level overseas talent.

Improve the introduction of excellent overseas talent and intelligence in low carbon areas, establish and improve preferential policies, incentive mechanisms and assessment systems for talent introduction and widen channels to introduce high-level technical talent; improve flexible introduction mechanism combining talent, intelligence and projects and encourage to introduce excellent overseas talent in flexible manners such as consultation, giving lectures and technical cooperation.

3. Strengthen popular awareness of low carbon science.

Make the development of low carbon economy an important part of improving the public's scientific awareness, establish publicity mechanisma integrated with government, media, enterprises and the public, actively carry out activities to popularize scientific knowledge nationwide, improve the awareness of enterprises and the social public in low carbon area and guide low carbon production of enterprises and low carbon consumption of the social public.

6.3 Policy roadmap

Based on details of phased goals of low carbon Industrialization in 2020, the above policies should be employed to promote low carbon Industrialization and make clear policy choices and emphasis at successive phases.

The key policies required to implement a low carbon Industrialization strategy in China are set out below, separated into actions for the 12th and 13th Five Year Plan periods.

Table 6-6: Policy implementation road map and key policy priorities

Phase I **2011–15**	1) Sectoral targets for energy-intensive industry are designed and introduced 2) Support for strategic emerging industries is scaled up, especially on innovation that will be important for their development by 2020 and 2030 3) China's energy pricing system and subsidies are reformed 4) A carbon tax is introduced 5) Pilot emissions trading schemes are started in some regions and industries 6) A 'top runner' program is designed and implemented 7) China's low carbon pilot areas use targeted fiscal and tax policies and

	credit support to accelerate investment, supported by the national government 8) There is tougher enforcement of energy-efficiency standards in industry and buildings 9) The coverage of mandatory labelling for energy and emissions is expanded and carbon footprinting methodology is approved
Phase II **2016–20**	1) Innovation is increasingly targeted at advanced, transformative technologies and materials needed to maintain competitiveness in the 2020s 2) Energy prices are set according to the market 3) Carbon tax rates gradually increase, encouraging low carbon investment 4) Green taxation makes a growing contribution to China's fiscal revenue 5) The top-runner program is in its second phase, now covering a wide range of industrial, commercial and domestic technology categories 6) A national carbon emissions trading system is introduced 7) A fully-fledged carbon finance system is achieved 8) Carbon footprinting and labelling are promoted, giving much greater visibility to energy and emissions performance for consumers

7 APPENDIX: MODEL METHOD FOR THE SCENARIO ANALYSIS OF LOW CARBON INDUSTRIALIZATION.

7.1 Scenario analysis

At the United Nations Climate Change Conference 2009, China raised by 2020, the carbon dioxide emission per unit GDP will fall 40%—45% on the basis of 2005, which is included in the middle and long term planning for national economic and social development as a binding indicator, and relevant statistics, monitoring and evaluation methods are developed; through actions such as vigorously developing renewable energy sources and actively promoting construction of nuclear power, China’s non-fossil energy will account for 15% in primary energy consumption; through forest planting and forest administration, the forest area will increase by 40 million hectare than 2005 and the forest reserve will increase by 1.3 billion m^3 than 2005. After China established the goal of about 20% reduction of GDP energy intensity during the 11th Five-year Plan, this is a strategic choice to plan as a whole domestic energy saving and consumption reduction and construction of two-oriented society and international cooperation to cope with climate change, meets China’s actual conditions and features of the development stage, reflects the common but different responsibility principle and is the independent action adopted by China according its real conditions and a great effort made by China to deal with the global climate exchange.

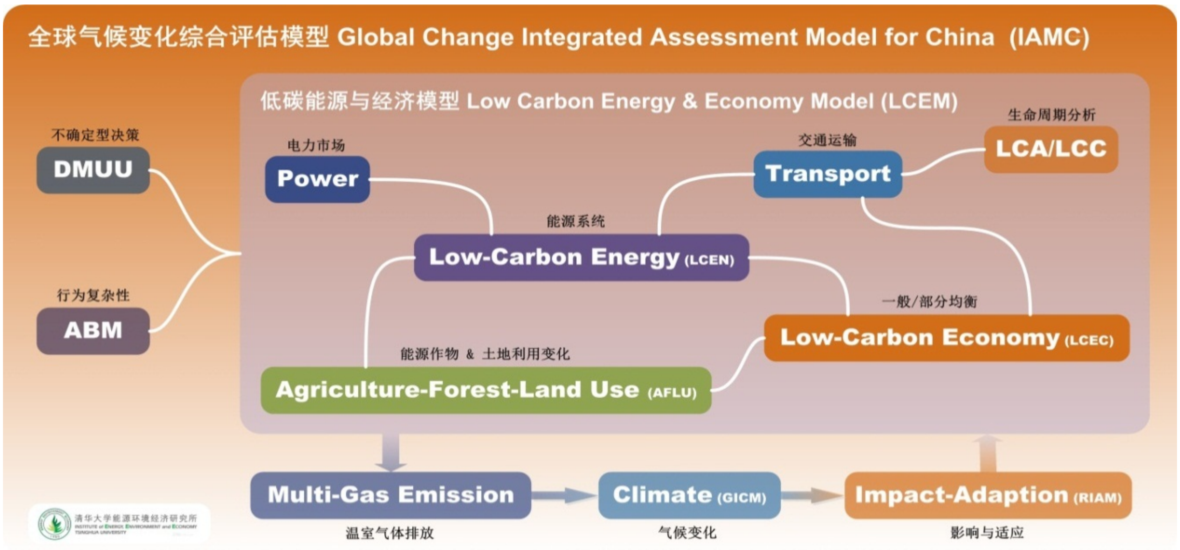
China is in a critical period of building a moderately prosperous society in all respects and at an important stage to accelerate to develop Industrialization and urbanization; the task is very heavy to development economy and improve the people's livelihood. China has large population, the level of economic development is low with acute structural imbalance in economy, coal is the main component in energy structure and energy demand will continue to grow. Although great efforts have been made in saving energy and optimizing energy structure and dramatic achievements made, it’s hard to change the huge total volume and the fast-growing trend of energy consumption and corresponding carbon emission. It is faced with huge pressure and special difficulty to control greenhouse gas emission. Extreme efforts need to be made to fulfill the above action goals.

In order to study the influence of China’s realization of 2020 carbon intensity objective on economy, industry, energy consumption and other aspects, based on Low Carbon Energy & Economy Model (LCEM) established by Institute of Energy, Environment and Economy, Tsinghua University, this paper optimizes the approach to realize the action goal and conducts scenario analysis.

7.1.1 Introduction of LCEM

LCEM（Low Carbon Energy & Economy）is a low carbon development integrated assessment model coupled by three sub-models (LCEC, LCEN and AFLU). The base year is 1999 and the simulation period is 2005-2020. It is a global model and in this research, it mainly involves issues within China. The integrated model framework is shown in Figure 7-1.

Figure 7-1: Global Change Integrated Assessment Model for China (IAMC)



LCEC (Low Carbon Economy Module) is a macro-economy growth model of general equilibrium and aimed to evaluate the influence of global and regional climate change and the economic cost of different policies and measures to deal with climate change as well as the influence on economic growth and social benefits. LCEC is an intertemporal optimization model, with social benefit optimization and intertemporal consumption as the goal. LCEN (Low Carbon Energy Module) is an energy technology model from bottom to top. The terminal energy service is divided into 8 sectors: agriculture, industry (high energy consumption industry and other industries), transportation (freight transport, passenger transport and international shipping) and building (commerce and housing). Specifically, high energy consumption industry includes steel, building material (cement), oil refining and petrochemical industry, papermaking, chemical engineering, aluminum and non-ferrous metal smelting and others, and its energy service includes boilers, heat treatment, mechanical drive, electrochemical treatment, material supply and other uses; commerce building sector's energy services include heating, refrigeration, hot water, lighting, office equipment and other services; house building sector's energy services include heating, refrigeration, hot water, lighting, electrical equipment and other services. LCEN model includes detailed independently-running sub-models of electricity generation technology and electricity market competition, communications and transportation technology and market competition sub-models. AFLU (Agriculture-Forest-Land Use Module) is a simplified agricultural technology model and used to study greenhouse gas emission of agricultural sectors such as agriculture, forestry and husbandry, greenhouse gas emission of land use changes, generation of biomass energy and its influence on land resource use, crop production, forest carbon sinks and others.

The simulation of industrial sector adopts TECGE, including 8 modules: production module, price module, income module, consumption and deposit module, investment and capital accumulation module, trade module, environment module and market equilibrium module; it can be divided into sectors such as agriculture, industry (nonmetallic mineral product industry, petroleum processing, coking and nuclear fuel processing industry, non-ferrous metal smelting and calendaring processing industry, ferrous metal smelting and calendaring processing industry, chemical material and chemical product production industry, chemical fiber production industry, papermaking and paper production industry, textile industry and other industries), energy (coal, oil, gas and power), transportation (railway, civil aviation, water transport, highway and pipeline), building industry and service industry.

7.1.2 Definition of China's LCIS

China's low carbon Industrialization scenario is defined as follows:

(1) Reference scenario: social and economic development trend and technical change before 2005 continues, no extra emission reduction targets and policy incentives;

(2) Target scenario of carbon intensity: continue to use the assumption of social and economic parameter in reference scenario, continue to study the realization of carbon intensity targets under different economic growth rates, continue to use the assumption of technical advance in reference scenario, restrained by independent emission reduction actions such as GDP carbon intensity target (40-45%), non-fossil energy development target (15%) and forest carbon sink target (40 million hectare) all in 2020 relative to the basis year of 2005, consider the reduction rate of two different carbon intensities (FF&I and FF&I&LULUCF), totally three kinds of carbon intensity (CI-40, CI-45 and CI-50) scenario.

(3) Technology scenario of low carbon Industrialization: continue to use the assumption of other social and economic parameters in reference scenario, restrained by independent emission reduction actions such as GDP carbon intensity target (FF&I- 45%), non-fossil energy development target (15%) and forest carbon sink target (40 million hectare) all in 2020 relative to the basis year of 2005, scenario of progress rate of main product technology index (unit energy consumption and emission) of totally three types of energy-intensive industries (CI-45TL, CI-45TM and CI-45TH).

(4) Policy scenario of low carbon Industrialization: continue to use the assumption of other social and economic parameters in reference scenario, restrained by independent emission reduction actions such as GDP carbon intensity target (FF&I- 45%), non-fossil energy development target (15%) and forest carbon sink target (40 million hectare) all in 2020 relative to the basis year of 2005, adopt the scenario of carbon tax of cascade tax rate during the 12th Five-Year Plan and the 13th Five-Year Plan.

(5) Integrated scenario of low carbon Industrialization: continue to use the assumption of other social and economic parameters in reference scenario, restrained by independent emission reduction actions such as GDP carbon intensity target (FF&I- 45%), non-fossil energy development target (15%) and forest carbon sink target (40 million hectare) all in 2020 relative to the basis year of 2005, fully reflect the scenario of energy price change.

7.1.3 Assumption of main social and economic conditions of China

1 Population and urbanization

The population of China remains steady growth this year. People generally think the total population of China will reach the peak around 2030. The population is likely to increase to 1.41 billion during the 12th Five-year Plan and to 1.44 billion by 2020; but at the same time, the labor force participation rate will tend to decline slowly during the 12th Five-year Plan and may fall from 60% in 2005 to 59% in 2015 and 57% in 2020.

Currently, China has entered the fast development stage of urbanization. During the 12th Five-year Plan, the urbanization rate is expected to increase to about 54% and it will reach about 63% by 2020; during the 12th Five-year Plan, the household number of urban residents will reach 266 million, the household size is about 2.84, and the average living area per household will reach 92.3 m^2; the household number of rural residents will reach 178 million, the household size is about 3.65, and the average living area per household will reach 138.7 m^2

2 Economic growth rate

China's social and economic development target is to try to make GDP of 2020 quadruple that of 2000 and GDP per capita of 2020 quadruple that of 2000. It is generally thought during the 12th Five-year Plan, the annual growth of GDP will maintain at 7%-9%, with the average of 8.6%; during the 13th Five-year Plan, the annual growth of GDP will maintain at 6%-8%, with the average of 7.2%. Calculated at constant price of 2005, China's GDP of 2010 will reach RMB 36 trillion, with GDP per capita of more than RMB 25,000; during the 12th Five-year Plan, China's GDP will reach RMB 50-55 trillion, with GDP per capita of more than RMB 35,000-39,000; by 2020, China's GDP will reach RMB 67-80 trillion, with GDP per capita of more than RMB 46,000-56,000.

Table 7-1 - Social and economic parameters

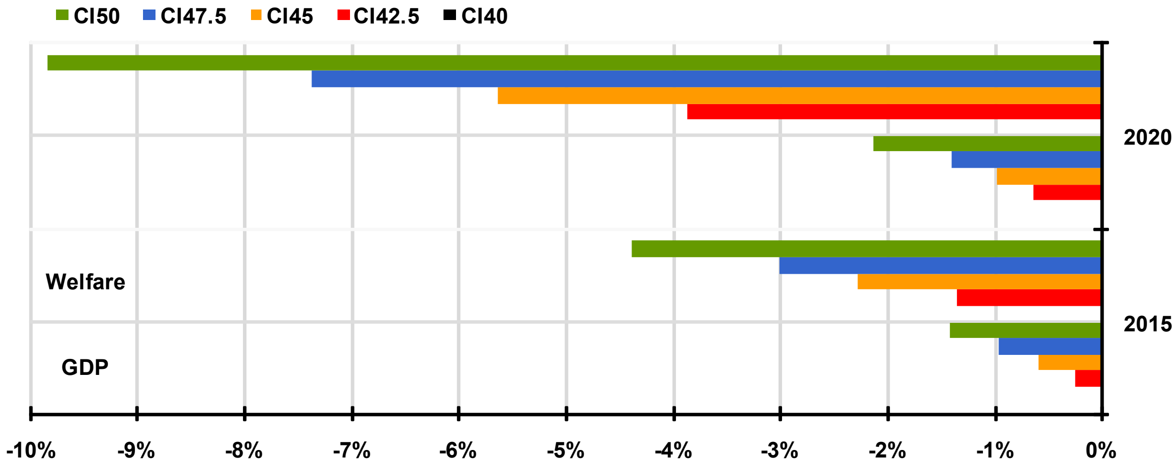
	2005	2010	2015	2020
Population (million)	1,308	1,360	1,408	1,440
Rate of urbanization (%)	43	49	54	63
Labor force participation rate (%)	60	61	59	57
Urban				
Residents (million)	562.44	666.4	757.5	907.2
Household size(persons/household)	2.96	2.88	2.84	2.8
Household number (million)	190	222	266	288
Rural				
Residents (million)	745	694	533	533
Household size(persons/household)	4.08	3.8	3.65	3.5
Household number (million)	183	190	178	181

7.1.4 Cost analysis of different scenarios

1. Welfare loss of consumers

Different carbon intensity policy targets have certain influence on economic and social welfare. With the 40% reduction target as benchmark, the 40-45% reduction target of carbon intensity has less than 1% influence on both 2015 and 2020 GDP, and the influence on welfare (or consumption) is about 1-5%, which is shown in Appendix 1. The annual average GDP growth rate will maintain at about 8-9% during 2011-1015, and at about 7-7.5% during 2016-2020. If more strict carbon intensity reduction target is implemented (such as 50%), the GDP loss of 2015 and 2020 will reach 1.4% and 2.1% respectively, and the welfare (or consumption) loss will reach 4.4% and 9.8% or so.

Figure 7-2: Influence of different carbon intensity policy targets on economic and social welfare



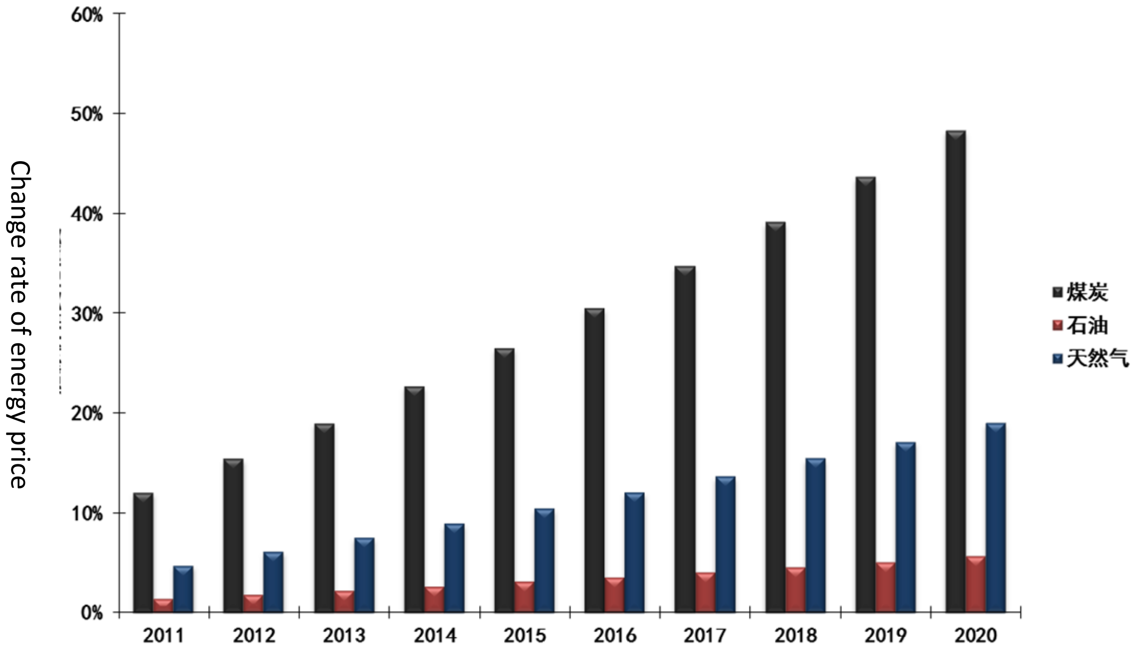
Source: LCIS Task Force analysis

2. Change of energy price

The model mainly studies scenario to fully reflect energy price change during the 12th Five-Year Plan and the 13th Five-Year Plan under constraint of a 45% reduction of carbon intensity of economic sector relative to 2005, and identify energy price change level.

Under the target of a 45% carbon intensity reduction, the price level of energy products is shown in Appendix2. Relative to reference scenario, coal, oil and gas prices will rise by about 26.5%, 3.1% and 10.4% in 2015, respectively, and about 48.3%, 5.6% and 19.0% in 2020, respectively. The increase of energy prices will cause great pressure on the upgoing price level. It needs to be considered to intervene in carbon intensity targets and potential carbon tax policies in certain regions and industries as well as to give appropriate subsidy to production and consumption sectors.

Figure 7-3: Energy price level during the 12th Five-Year Plan and the 13th Five-Year Plan, with a 45% reduction target of carbon intensity



This Task Force Report is submitted to CCICED
with the Co-Chairs' approval

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2. Direct geothermic utilization includes ground source heat pump, bath, swimming, and regular geothermic heating as well as greenhouse, aquatic product, industry and snow melting etc. Ground source heat pump accounts for 49% of direct geothermic utilization in the world and 41% in China. (Statistics from 2009)

3. In China, methane is mainly for domestic use in rural area and is produced by medium and large scaled methane projects, while in the U.S, methane is largely produced at refuse landfill and cattle farm.

85 1. In the calculation of comprehensive energy consumption, both at home and abroad, electricity consumption is converted to coal consumption for power generation uniformly.

2. Gap stands for how many percentage points higher China is than international advanced level.

3. For coal consumption of thermal power supply, the figure of China comes from the average value of units over 6MW and that of international advanced level comes from the average value of Japan's 9 major electricity companies. In China and Japan's power source structures of 2006, coal-derived electricity accounts for 81.33% and 26.03% respectively, while electricity produced from oil and gas makes up 1.97% and 34.68%. Comparable energy consumption of steel is mainly for large and medium-sized enterprises in China, whose output accounted for 86.2% of the total in 2010. International advanced level was South Korea's average value in 2005 and Japan's average value in 2010. Canadian company Alma represents international advanced level of electrolytic aluminum power consumption and Middle East stands for international advanced level of comprehensive ethylene energy consumption. These countries use ethane as raw materials while China uses naphtha.

86 1. The comprehensive energy consumption of the steel industry refers to larger and medium-sized steel enterprises, which contributed 86.2% to the total steel production in 2010.

2. The comprehensive energy consumption of power consumption is calculated with coal consumption in power generation.

3. In the volume of production, the production of oil refining refers to the processing amount of crude oil; the production of glass sheets is calculated in weight cases, and the rest in Mt.

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National Development and Reform Commission and some relevant departments started this movement, aiming to save 100 million tce energy accumulatively in 11th Five year plan period.

90 Those 79 kinds of existing industrial energy conservation technologies include: 18 in electricity (4 are advanced thermal power generation technologies) ; 11 in steel; 15 in building materials; 17 in petrochemical industry; 9 in non-ferrous metal; 5 in textile; 4 in papermaking

91 The investment requirement in promotion and application of energy efficiency technologies in energy intensive industrial sectors only take those added cost for increasing energy efficiency into account.

92 Electricity consumption in the comprehensive energy consumption of per ton steel production is converted to the equivalent value.

93 Electricity consumption in the comprehensive energy consumption of cement production is converted to equivalent value.

94 In comprehensive energy consumption of paper and paperboard per unit product, electricity is converted according to equivalent weight method

95 These statistics only cover enterprises above designated scale.

96 Source: from China Statistical Yearbook.

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102 1. International advanced level refers to the average level of advanced countries.

2. Total energy consumption of major products in China and abroad adopts standard coal to calculate electricity consumption. Since 2007, China applies coal consumption of power generation (about 350 gce/kWh) in China Energy Balance Sheet, while Japan, representing international advanced level, calculates with 350 gce/kWh.

3. In terms of coal consumption of thermal power supply, China only counts generators with over 6MW capacity while Japan calculates the average value of nine major power companies. Electricity consumption and heat consumption of oil-fired and gas-fired power plants are lower than thermal power plants. In 2006, coal, oil and gas takes up 81.23%, 1.46% and 0.51% respectively in the electricity generating resources mix, while those figures for Japan are 26.03%, 10.58% and 24.1% respectively. Service power consumption rate for Chinese power stations is 5.93% and that for Japan is 3.86%.

4. The comparable energy consumption of steel in China only refers to large and medium enterprises. In 2008, 70 large and medium sized steel companies produces 83% of the country's steel. 1990, 2000 and 2008 "international advanced level" is represented by Japan, and the 2005 figure is the average level of 31 South Korean companies.

5. The 1990 and 2000 total energy consumption of ethylene is represented by Japan, while 2005 and 2008 is the average level of Middle East countries. China and Japan mainly use naphtha as the raw material of ethylene production, while Middle East Region utilizes ethane.

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