China's Pathway Towards a Low Carbon Economy

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Task Force Report on China's Pathway toward a Low Carbon Economy

Summary Report

Today, it is widely accepted that global climate change presents one of the biggest challenges for human development. At the global level, the scientific consensus is driving global action towards emission reduction and the transition to a low carbon economy. Some developed countries have substantially adjusted and continue to change their socio-economic policies in a move towards low carbon development. Trade-related greenhouse gas (GHG) emissions are also likely to come under increasing scrutiny in the coming decades. This is especially acute for emerging economies dependent on export-led growth. These concerns bring structural changes to the global economy and trade patterns that imply a new paradigm for economic development.

Already frequently stricken by natural disasters, a further increase in the number of climate-related natural disasters would incur not only ecological and economic losses to China, but also threaten domestic social stability. Growing industrialization and urbanization together with China's continuing coal-based energy structure (at least in the short-run) imposes tremendous pressure on China's resources and environment. Increasing dependency on imports of oil not only raises uncertainties for economic development but also worsens energy security. With global economic imbalances causing financial crises, the pattern of economic growth in China is facing unprecedented challenges.

Against this backdrop, the move towards a low carbon economy is an inevitable path for China if it is to realize its development goals. Developing a low carbon economy is of critical strategic importance for China as the country evolves its economic development model, adjusts its economic structure, enhances its technological innovation capacity, and strengthens the sustainability of its economy. In recent years, China has already adopted rigorous energy conservation and emission reduction policies that are important to kick-start a low carbon economy. Looking ahead, China stands to benefit significantly from a transformation of its pattern of economic growth. Such a transformation will allow China to capitalize on new growth opportunities as a supplier to satisfy increasing global demand for low carbon technologies.

1 Global Shift to a low carbon economy

In this report, a Low Carbon Economy (LCE) is defined as a new economic, technological and social system of production and consumption to conserve energy and reduce greenhouse gas emissions compared with the traditional economic system, whilst maintaining momentum towards economic and social development.

This definition is underpinned by three principles:

a) A LCE would eventually decouple economic growth from greenhouse gas and other polluting emissions, through technological and other innovations and changes in infrastructure and behavioural changes.

b) At China's current stage of development, still undergoing industrialization and urbanization, "Low Carbon[1]" is a relative rather than an absolute concept. Emissions per unit of economic output are reduced more rapidly under a LCE than would be the case with a continuation of the status quo.

c) A Low Carbon Economy achieves many key development objectives including long term economic growth, creation of jobs and economic opportunities, reduction of resource consumption, and enhancement of technological innovation.

To avoid dangerous levels of climate change, global temperature rises need to be restricted to no more than 2˚C above pre-industrial level. To realize this goal, global emissions will need to peak within the next ten years; they will need to be halved or more by 2050. In order to achieve this, energy systems that are close to zero emissions will need to be developed. Eventually these will need to be implemented globally. Different development situations will mean countries have different pathways to a low carbon economy. Consequently this report does not make specific recommendations on absolute emissions targets for China, focusing instead on relative measures of carbon intensity and energy consumption.

The cost of low carbon transition is a critical issue for policymakers today. In practice, the overall costs of CO_2 reduction are likely to be lower than expected. In many sectors clean technologies already exist and reduction measures are low cost or even profitable, for example in energy conservation, efficiency and renewable energy production. However, cost estimates vary quite widely. This is partly because technology costs are uncertain, and are dependent on the global price of oil, which can fluctuate significantly. McKinsey's CO_2 abatement cost curve[2] suggests that approximately one third of the 36GtCO_2 affordable global abatement opportunities in 2030 are achievable at negative cost (i.e. representing a net economic benefit even without considering reduced climate damages). McKinsey also estimate that the total costs of mitigation will be on the order of 0.6-1.4 % of global GDP by 2050.[3] The negative cost options are mostly associated with energy efficiency improvements. The Stern Review indicated that the total global costs of meeting a stabilization target sufficient to avoid the worst effects of climate change could range from -3.9% of world GDP (i.e. a net benefit) to +3.4% of world GDP in 2030[4].

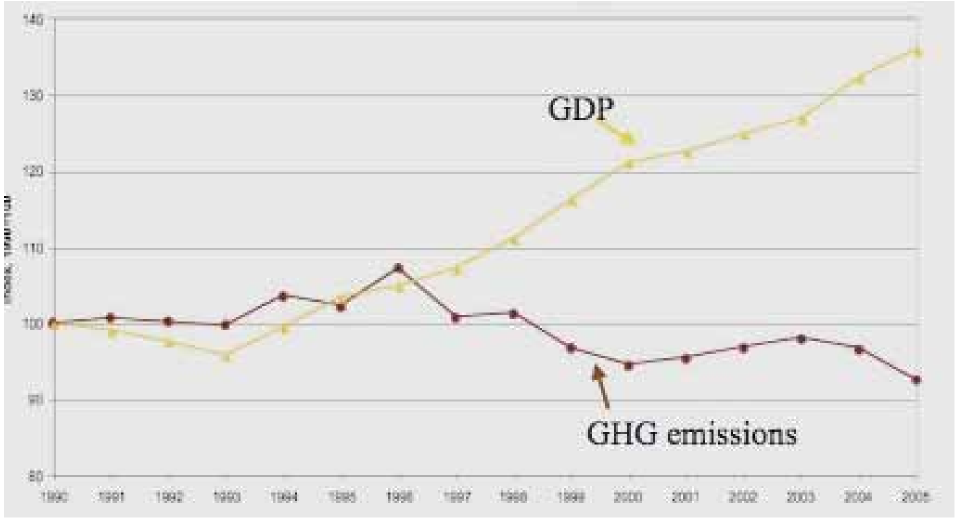
Central to the vision for a low carbon economic future is increasing appreciation of the potential economic, social and political benefits – rather than the costs – of the transition. A recent study estimates that China alone will need $25 billion per year for investment in low carbon technologies.[5] Globally, the value of low carbon energy products are estimated by the Stern Review[6] to be worth at least $500 billion per year by 2050, and perhaps much more. According to the International Energy Agency (IEA) meeting a 450 ppm CO_2e concentration limit would require an increase in investment of 18%, averaging an additional $1 trillion per year up to 2050 compared to the Business-as-usual (BAU) requirements.[7]

At the global level, the transition to a low carbon economy is no longer a choice but a necessity. Fluctuating prices and supply volatility are motivating the more efficient use of resources. The tightening global supply of oil and natural gas – as well as the imperative of climate mitigation – is fuelling the development of new technologies.

With deeper acceptance of the findings of climate-related science, the question today is less about whether low carbon transition is needed but how fast can it be implemented and at what scale. The low carbon economy can not only be a useful way through the current economic crisis but is the most viable means to ensure sustained growth in the medium and long term. Investment opportunities in low carbon goods and services may become increasingly appealing compared to risks associated with investing in traditional sectors. A global assessment undertaken by Greenpeace International and the European Renewable Energy Council pointed to a net increase of nearly 2 million jobs in the power sector as a result of increased use of renewable energy by 2030[8].

As the case of Sweden demonstrates in Figure 1, it is possible to achieve GDP growth while emissions fall, although not many developed countries have so far been able to emulate Sweden's example.

Figure 1 Sweden: Growing GDP with emissions reductions



Source: Swedish Energy Agency, 2008

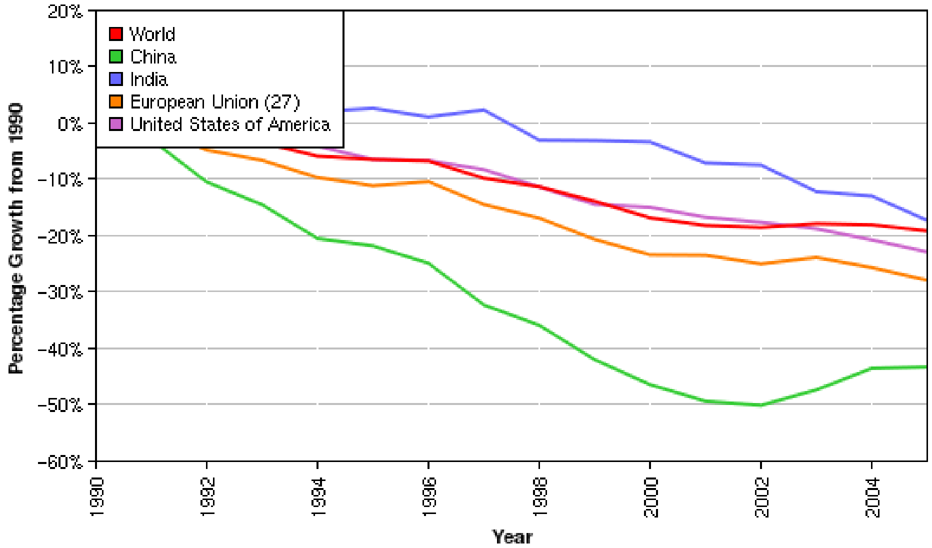
1). Avoiding high future costs The economic case for immediate transition to low carbon economy is compelling. The macroeconomic cost of transition is likely to be manageable. On the other hand, the Stern Review puts the costs of inaction on climate change at between 5% and 20% of GDP: the combined cost of both World Wars and the Great Depression. One needs look no further than losses associated with extreme weather-related events to comprehend the potential scale of impacts. Global economic loss attributed to climate related disasters reached an unprecedented 185 billion dollars in 2005. The United Nations projects that weather disasters could cost a trillion dollars (or 3% of current global GDP) per year by 2040.[9] In just one example in China, the 2005 drought in Ningxia Hui Autonomous Region cost an estimated 1.27 billion RMB – 2% of its GDP – damaging 289,000 hectares of crops.[10]

2). Avoiding dangerous carbon lock-in Carbon 'lock-in'[11] describes a situation whereby due to economies of scale, a country's technological and institutional infrastructures co-evolve towards dependency on fossil-fuel-based systems. Work undertaken for the Dutch Environmental Assessment Agency suggests that delaying the peaking of global emissions by 10 years doubles the maximum emission reduction rates needed from 2.5% to over 5% per year, when compared to immediate action. This leads to far higher costs as high-carbon infrastructure and equipment installed over the next decade would subsequently need to be scrapped before the end of its economic lifetime.[12]

Our decisions in the next 10-15 years will determine whether or not a climate-safe future will be possible. Lock-in is equally important for decisions on public transport, urban design, construction standards and major industrial investments. Lock-in will also blunt attempts to capitalise on the competitiveness possibilities. It will be enormously expensive to correct poor decisions post hoc.

3). Ensuring energy security Achieving energy security is a major driver for China's low carbon development. Policies such as diversifying energy sources and improving end-use efficiency – both necessary to ensure energy security – are contributing to the shift into low carbon options. The Chinese economy is over four times less energy efficient than that of the EU measured in terms of consumption per unit of GDP at current prices. To respond to climate change and achieve energy security together, China can continue to place great emphasis on energy efficiency whilst investing in low carbon options in the power and transport sector to reduce dependence on fossil fuels.

Figure 2 Global Carbon Intensity Trends



Source: WRI 2009

4). Trade in a carbon-constrained world Trade and investment can facilitate the worldwide transition to a low carbon economy through the creation of new market incentives. Trade and investment also enhances access to countries' comparative advantages, leading to cheaper inputs and prices. Despite the benefits brought by global trade, trade-related CO_2 emissions are likely to come under increasing scrutiny in the coming months. This is especially problematic for emerging economies dependent on export-led growth. Many US legislators have championed proposals to impose border tariffs on exports from developing countries not taking 'comparable actions' to limit GHG emissions. These ideas are also favoured by a number of European governments and legislators.

Table 1 below indicates a range of actions by both developed and developing countries either to achieve a particular level of abatement or to cap national emissions. All these policy developments and the abatement initiatives taken to meet them – whether from governments, businesses or consumers – are redefining the calculus for exporting countries. To ensure long term survival, it is becoming critical for exporters to understand and adapt to the dynamics of an increasingly carbon-constrained world.

Table 1 Strategic action for a low carbon economy - selected countries

Country	*Action*
Australia:	Cap and trade 'Carbon Pollution Reduction Scheme' to be phased in from 1 July 2011 and a commitment to reduce carbon emissions by 25 per cent below 2000 levels by 2020 (pending UNFCCC post-Kyoto agreement).
Brazil:	Implementation of a 'National Policy for Energy Efficiency' that will result in a gradual energy saving up to 106 TWh/year to be reached by 2030, a reduction of emissions of around 30 million tons of carbon in that year.
Costa Rica	Pledged to be carbon neutral by 2021.
France:	Emission reductions of the order of 75 – 80 per cent before 2050 if other countries do the same (a conditional target).
UK:	2008 Climate Change requires legally binding 5 year carbon budgets to be set by an independent expert committee. The Act requires emission reductions through action in the UK and abroad of at least 80% by 2050. The carbon budget for 2020 is set at 34% reduction compared to 1990, increasing to 42% following a global deal on climate change. Pledge to build no new coal-fired

	power stations without CCS to capture at least 25% of carbon emissions and 100% of emissions by 2025.
Mexico	Planning a domestic cap-and-trade system by 2012 to cut emissions from certain sectors (cement, oil refining etc.). The government has pledged to halve carbon emissions by 2050 on 2002 levels.
Norway:	Aim of being carbon neutral by 2030. Has committed 140 million Euros over 5 years CCS projects in selected EU member states.
South Africa:	A plan to halt its growth of greenhouse gas emissions at the latest by 2020-2025 and to adopt various economic and policy measures so that emissions will eventually stabilise and decline.
Sweden:	In 2000 Sweden discussed a target of reducing own emissions by 50 % from 1990 level before year 2050. The government has said that Sweden should work internationally for stabilising the concentration of greenhouse gases at a level below 550 ppm CO2-equivalents. Swedish per capita emissions should be below 4.5 tonnes CO2-equivalents before 2050. This represents a reduction of just over 40 % compared to today's level. The 2008 budget included 7 billion Krona for climate and energy initiatives between 2009-2011.
United States	The government has suggested a 14-15 % reduction in carbon emissions from 2005 levels by 2020. The Waxman-Markey Bill (recently passed US House of Representatives, now facing the Senate) calls for an absolute cap covering 85% of the US economy, resulting in a 17% reduction by 2020 and over 80% reduction by 2050 compared to 2005 levels. The Bill requires electric utilities to meet 15% of their electricity demand through renewable energy sources and energy efficiency by 2020 and outlines US$90 billion in new investments in clean energy technologies and energy efficiency by 2025.
Japan	The incoming Prime Minister has stated that Japan would seek to reduce CO2 emissions by 25% below 1990 levels by 2020. This target would be contingent on a deal involving all major emitters in Copenhagen in December 2009
EU	Committed to cutting carbon emissions by 30% of 1990 levels by 2020 (pending UNFCCC post-Kyoto agreement). The 2007 EU climate and energy package has set 3 additional targets to be met by 2020: a 20% reduction in energy consumption compared with projected trends; an increase to 20% in renewable energies' share of total energy consumption; and an increase to 10% in the share of petrol and diesel consumption from sustainably-produced biofuels.

2. Necessity and urgency of developing a low carbon economy in China

2.1. Low carbon economy is consistent with the strategic goal of scientific development

A low carbon development pathway is the best way for China to achieve a resilient and prosperous society, while building on and enhancing China's priorities such as the Scientific Outlook on Development, the construction of a resource-saving, environmentally-friendly society, and the development of a circular economy. Efforts to maintain a safe climate is in line with the Chinese priority of developing a harmonious society, and is fully consistent with existing Chinese efforts on energy saving and environmental protection. The low carbon economy provides a pathway to the new industrial and economic growth model that China urgently seeks.

China has experienced a remarkable economic expansion over the past three decades, triggered by domestic reform targeted at rapid industrialisation and urbanisation, coupled with opening its economy to international trade. Today, China is the third largest economy and the third largest exporter in the world. Its economic status is likely to grow in the next 20 years, together with corresponding expansion in scale of industrialisation and urbanisation. However, the Chinese economy also faces immense challenges. First, the current trends are not sustainable, with high resource pressures on the environment. China also needs to tackle the threat of climate change, including adapting to its impacts. Its industrial structure remains sub-optimal, with weak innovative capacities. Its comparative advantage in low value addition production has also been weakened especially following the global financial and economic crisis. Export-oriented economies like China face great pressures in an increasingly uncertain global economic setting.

China’s existing model of development is therefore not sustainable. Current growth rates in energy consumption will lead China to be increasingly dependent on imports of coal, as well as increasingly dependent on imports of oil and gas with higher world prices. In 2006, China’s GDP accounted for 5.5% of the world total; its energy, steel and cement consumption respectively accounted for 15%, 30% and 54%. Climate change already threatens to reduce crop yields through water-stress and extreme weather, and if it goes unmitigated climate change will severely impede China’s development.

Globalization has not only led to an international redistribution of industrial production; it has also meant a redistribution of energy and resource consumption, and hence, emissions. According to the World Energy Outlook 2007: China and India Insights, the amount of energy ‘re-exported’ by China in 2004 was 400 million tons of oil equivalent (Mtoe), amounting to 25% of the country’s energy consumption. The amount of energy embodied in the commodities China imported that year was 171 Mtoe, amounting to 10% of energy demand. The proportion of energy embodied in the commodities China exports is much higher than that for other countries (for the US, the EU and Japan, the figures are 6%, 7% and 10% respectively). This high proportion exacerbates the rise of China’s carbon dioxide emissions.

International economic structures and trade rules are changing in response to energy and resource constraints, as well as in response to financial instability caused by unsustainable trade flow imbalances. While a global move to a low carbon economy places pressures on China’s development, it also rings great opportunities for future growth. A move towards a low carbon economy can address the challenges outlined above, and realise the long term goal of sustainable growth.

Developing a low carbon economy presents China with an opportunity to leapfrog the process of resource-intensive, highly polluting growth experienced by Western countries. There are additional incentives for China to move towards more efficient manufacturing processes and towards a lower-carbon industrial structure in order to stay at the forefront of international trade.

In short, China’s move towards a low carbon economy is inevitable, necessary and urgent. There are considerable benefits to China of taking early action. China needs to avoid lock-in to energy-intensive urban and industrial infrastructure. Investments made now and over the next decade will determine China’s exposure to energy security and climate change risks for decades to come. By acting now on R&D and commercialization activities, China can take a leading role as a supplier of equipment and know-how to rapidly growing international markets for low carbon technologies, goods and services. These changes will re-enforce China’s domestic aims of becoming less dependent on exports of heavy energy-intensive goods, and becoming a market leader in higher value-added technology- and information-based goods and services.

The country is already a world leader on critical low carbon technologies such solar power, heat and wind turbines and is rapidly developing key technologies for electric vehicles. Choices made in China will shape the global markets for such goods.

2.2. China is already shifting towards a Low Carbon Economy

Existing programmes provide a strong foundation for China to move along a low carbon economic pathway. China’s ‘Scientific Outlook on Development’ concept provides essential guidance for economic and social development. It emphasizes people-oriented development, which must be comprehensive, balanced and sustainable. This overall strategic approach sets the framework for more specific policies and actions.

The Eleventh Five-year Plan sets specific goals for a decrease in energy and resource intensity. It identifies "substantially improving the efficiency of resource utilization" as one of the main goals of economic growth and social development during the period the Plan, and sets the following targets:

- energy consumption per unit of GDP will be cut by around 20%
- water consumed per unit of industry value added will be reduced by 30%
- effective utilization coefficient of field irrigation water will be lifted to 0.5
- rate of industrial solid wastes utilized will be lifted to 60%.

China's National Climate Change Programme (CNCCP) outlines objectives, basic principles, key areas of actions, as well as policies and measures to address climate change for the period up to 2010. Guided by the Scientific Outlook on Development, China will carry out all the tasks in the CNCCP, strive to build a resource conservative and environmentally friendly society, enhance national capacity to mitigate and adapt to climate change, and make a further contribution to the protection of the global climate system.

According to the State Renewable Energy Medium- and Long-term Development Program, renewable energy is expected to account for 15% of China's total energy supply by 2020, up from 7% at present, with the capital support of around 1.5 trillion RMB (200 billion USD) from the government. (The Program is being further revised, and the renewable target may be adjusted upwards.) Nearly 40 million households will use biogas around the country by 2010 under the State Rural Biogas Development Programme (2006-2010), and annual biogas production will reach 15.4 billion cubic meters, which equals to energy consumption of 24.20 million tons of standard coal and 140 million *mu* (approximately 9.3 million hectares) of annual forest stock. Progress is on track: 31 million homes were using biogas sources for cooking and heating by the end of 2008, an increase of 5 million on the previous year. The use of wind power is also expected to increase significantly, with plans for upto 100 GW of installed capacity by 2020, up from around 12 GW in 2008.

2.3. Benefits for China are significant

China's move towards a low carbon economy will not just be a reactive response to external forces arising from shifts in global economic structure and pressure to reduce climate impacts. There are also very significant positive benefits to be gained for China as it moves to tackle its own internal energy resource and environmental constraints. It will alleviate resource and energy pressures; improve the structure of energy consumption; and safe-guard energy security.

Now is the time for China to make a decisive shift from its previous energy- and carbon-intensive development patterns to a more sustainable path. By acting now, China stands to gain by avoiding lock-in to inappropriate capital stock, positioning itself as a global leader and provider of low carbon technology, and making use of emerging carbon markets and other international financing mechanisms.

As a result of China's rapid industrialization and urbanization, massive amounts of infrastructure and equipment are set to be put into operation over the next 2 decades. Furthermore, in response to the global economic crisis, the Chinese government has launched a 4 trillion RMB direct fiscal stimulus plan. Together, this provides China with an extraordinary window of opportunity for reconstructing and upgrading domestic industries in China.

If this wave of investment fails to use advanced technologies, equipment, and infrastructure, China will lock in high energy consumption, high pollution and high emissions for their entire life-cycle — possibly for decades. China will therefore live with the decisions it is making during this decade for many decades to come.

At present, China is a global leader in terms of R&D and commercialisation for some low carbon technologies. However, public and private sectors from developed countries are also injecting large amounts of capital into low carbon R&D. Competition to develop and commercialize new technologies is fierce, and China must keep up. Once low carbon technologies go into in the stage of wide commercialization elsewhere, China would simply replicate its traditional pattern of becoming a home for low-cost competition, instead of establishing new international competitive advantages based on home-grown innovation.

China's 2006 *National Medium- and Long-term Science and Technology Development Planning Framework* spelled out specific targets for energy technology development. By 2020, Chinese researchers are anticipated to achieve breakthroughs in energy development and conservation technologies, clean energy technologies, as well as on the optimisation of the energy mix. Over the same period, major manufacturing industries are expected to reach or approach the energy efficiency level of advanced countries. The Ministry of Science and Technology (MOST) draws up the technology R&D plans and provides funding for the national programs.

One possible model that China is considering for incubating these developments builds on the experiences in the early 1980s when China embarked on an extraordinary journey towards greater economic openness. Special Economic Zones (SEZs) – geographical regions with more liberal economic laws than the rest of the country – played a vital role. Building on this successful model, a consortium of European and Chinese research institutes developed the concept of "low carbon zones" (LCZs), and are currently engaged in piloting and developing the methodology for LCZs in Jilin City Municipal Area.

3. Understanding challenges and opportunities

China faces challenges in the transition to a low carbon economy. It remains a developing economy, with low GDP per capita income. Capacities and income levels also vary across different regions. It is therefore critical to understand current constraints and to overcome a range of technological and institutional barriers.

Industrial structure A major factor is China's industrial structure. A large share of China's economy is in a stage of industrialization 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 significantly behind the world average. In addition, there is a dramatic variation among regions in China in terms of economic development level and industrialization stage.

China's energy-intensive industries are 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. Compounding this is China's natural endowment in terms of energy: huge reserves of coal, which encourages over-reliance on this carbon intensive source. Another obstacle relates to the shift in China's policy toolbox for promoting energy saving: from the current, largely administrative tools such as centrally-determined targets for local governments and enterprises, to a market-oriented approach. Inevitably there will be a time lag between the introduction of market mechanism and its implementation. There will also be a time lag before the benefits from investment in energy efficiency and emission reduction measures materialise.

Building sector China's building sector currently accounts for about 28% of the country's total energy consumption. China also has plans for major expansion of the housing sector, estimated to 20 billion m^2 by 2020, this equates to all the current housing stock in the EU 15. Part of the solution is to expand long-term fiscal and tax incentives for energy-saving in the construction sector, which are currently lacking.

Institutional barriers are a challenge. Currently, charges for central heating and cooling are based on floor-space, giving users no incentive to save energy. Many cities in China have introduced time-of-use (TOU) power policies, but many buildings are not installed with a TOU meter. Where mandatory building energy-saving standards exist, surveys show that only a small proportion of new residential buildings in large Chinese cities adhere to the standards: 50% for northern areas, 14% for areas with hot summer and cold winter, and only 11% or so for areas with hot summer and warm winter. China's policy on energy auditing for new buildings is yet to be effectively implemented. Because issues like energy-saving policy, energy price, fiscal and tax policy, and environmental protection cut across several government departments, an appropriate authority should be introduced to promote coherence.

Transport sector Globally the transport sector is the largest and fastest-growing emitter of CO_2. In China, the sector's energy consumption and emissions are likely to increase significantly in the coming years. A policy priority should be to decrease the rate of emission growth in the short term, and to develop alternative new technologies and mode of transport in the meantime. The introduction of stricter standards on vehicles (grams of CO2/km) has been shown to significantly increase average efficiency. Technological changes are not the only mechanism to lead to efficiency improvements. Behavioural changes could also bring considerable gains, such as altering driving habits, driving more slowly and evenly, car-pooling, and a switch to public transport for those that can afford cars. Some of these measures require relatively simple measures, such as changing speed limits or greater public awareness.

Innovation and R&D China must attach great importance to R&D, focusing on medium and long-term strategic technologies. It needs to support the rapid diffusion and use of existing commercial low carbon technologies, rationalize venture investment and financing to encourage companies to develop new low carbon technologies, and enhance international cooperation to promote technology transfer from developed countries to China.

Insufficient technological innovation capacity is a weakness of China's economy. The country is a large resource consumer, but its average economic output per unit of resource consumed is less than 10% of that of developed countries. China is the third largest trader, but only a tenth of its exports are accounted for by homegrown brands and intellectual property. China is a big manufacturer, but it needs to import major technical equipment. China's exports of high-tech products are growing, but it relies heavily on importing key components for those products, and has to pay the foreign companies large fees for software technology standards. Many enterprises spend much more on technology imports than on technology absorption and assimilation. On average, the proportion of investment on imports to that for absorption is 6.5:1; in Japan after World War II, it was 1:7 – more than reversed, although this partly reflects the much greater level of globalization today, with imports and exports of goods and services typically being a much greater part of many international companies' business models. "Strengthening capacities of independent innovation of information technology" is a major goal of China's State Informatization Development Strategy (2006-2020).

The deployment of low carbon technology Many (though not all) of the technologies that will enable a rapid, transformative change in the way energy is produced are already available, but not adequately deployed. Energy efficiency gains will only be achieved by a concerted effort across all sectors of society. The general public and other energy consumers will have to be engaged to ensure purchasing and investment decisions on the entire operational life of appliances, not only on upfront costs.

Lower- and zero-carbon supply options require market stability. Since in most cases, fossil fuel-based energy sources are currently cheaper than the low carbon alternatives, investors need both short term incentives and confidence in a longer term policy framework. For example, if the environmental costs can be internalized into product prices, on-shore wind power prices are already competitive. However, barriers such as access to the grid and planning regulations often inhibit new investment. Relatively simple measures could be introduced to prioritize these technologies, enabling their wider diffusion in existing markets. The removal of other barriers, such as prohibitive financing, overly burdensome regulations and difficult access to energy networks will also have to be addressed if rapid diffusion is to be achieved.

Supply chain bottle-necks Changing engineering standards and the materials used in the manufacture and use of goods can have widespread implications for supply chains. In particular, higher efficiency standards for buildings have been known to result in bottlenecks due to the shortages of specific energy-efficient materials, e.g. high spec windows. On paper, overcoming these potential blockages in the supply chain is simple: increase production. However, in practice it is more complicated, and may require a number of measures including clear medium and long term targets that facilitate R&D and investment; financial incentives for new production investment; increased co-operation and patent sharing to enable leapfrogging to the best available technology; and stricter penalties and regulation to avoid production based on redundant or soon to be redundant technologies.

Table 2 Barriers to the deployment of energy efficient technologies and practices

Barrier	Why?	How to overcome the barriers?
Low energy prices	-Subsidies -Prices do not include environmental costs	- Eliminate perverse subsidies - Provide aid to those who need them most through alternative mechanism - Put a price on carbon
High upfront costs and long pay back periods	-Most consumers value the present cost of consumption	-Fiscal incentives (e.g. tax reductions) to decrease upfront cost -Encourage financial institution participation
Slow diffusion of technologies	-Lack of skills, knowledge and support on the use of technologies -Fragmented and non integrated industry structures (e.g. building sector)	-Technology standards
Entrenched business models	-Lack of incentives for energy companies to reduce customer demand	-Internalize carbon prices in energy services -Financially reward end-user EE measures -Promote ESCOs -Encourage and incentives energy companies to promote cleaner energy, technologies and energy efficiencies
Diversity of consumers and energy needs	-No single solution fits all	-Promote voluntary sectoral initiatives and negotiated agreements
Information failures	-Lack of product performance information and EE alternatives - Uncertain future energy prices and development	-More effective technology standards (e.g. building codes) -Product energy labeling -Products energy performance information and labelling - -International EE standards benchmark and local standards enforcement -Encourage the 'smart meter' development
Split incentives (principal agent problem)	-Those making decisions on EE do not benefit (e.g. building owners and tenants)	-Provide clear information and incentives (e.g. tax rebates, mortgage discounts, rebates, preferential loans)
Uncertainties on investment and risks	-Uncertainties add a premium to investments	-Economic incentives that cover those risks -Develop robust energy and carbon markets
Consumer behavior	-Low priority of EE investments -Lack of awareness and information on energy consumption and costs	-Develop carbon markets -Incentives to remove and replace old equipment -Raise education and awareness on EE (for example through community-based initiatives)
Investment costs higher than expected	-Don't include all transaction costs	-Boost best practice sharing and EE education

Source: Developed by WBCSD and its member companies (2009)

4. Scenarios for Low Carbon Economy up to 2050

Four scenarios are developed for this study, which look at the implications of introducing low carbon technologies and practices at different rates on levels of energy use and the relative and absolute levels of CO2 emissions.

BaU under high growth rate: (BaU) Annual average growth rate between 2005 and 2050 is set to be 6.4%, representing the high economic growth prospect obtained in previous analyses. Characterized by high consumption mode and global investment, local pollution control, pollute first then mitigate, huge investment in technology and rapid technology improvement.

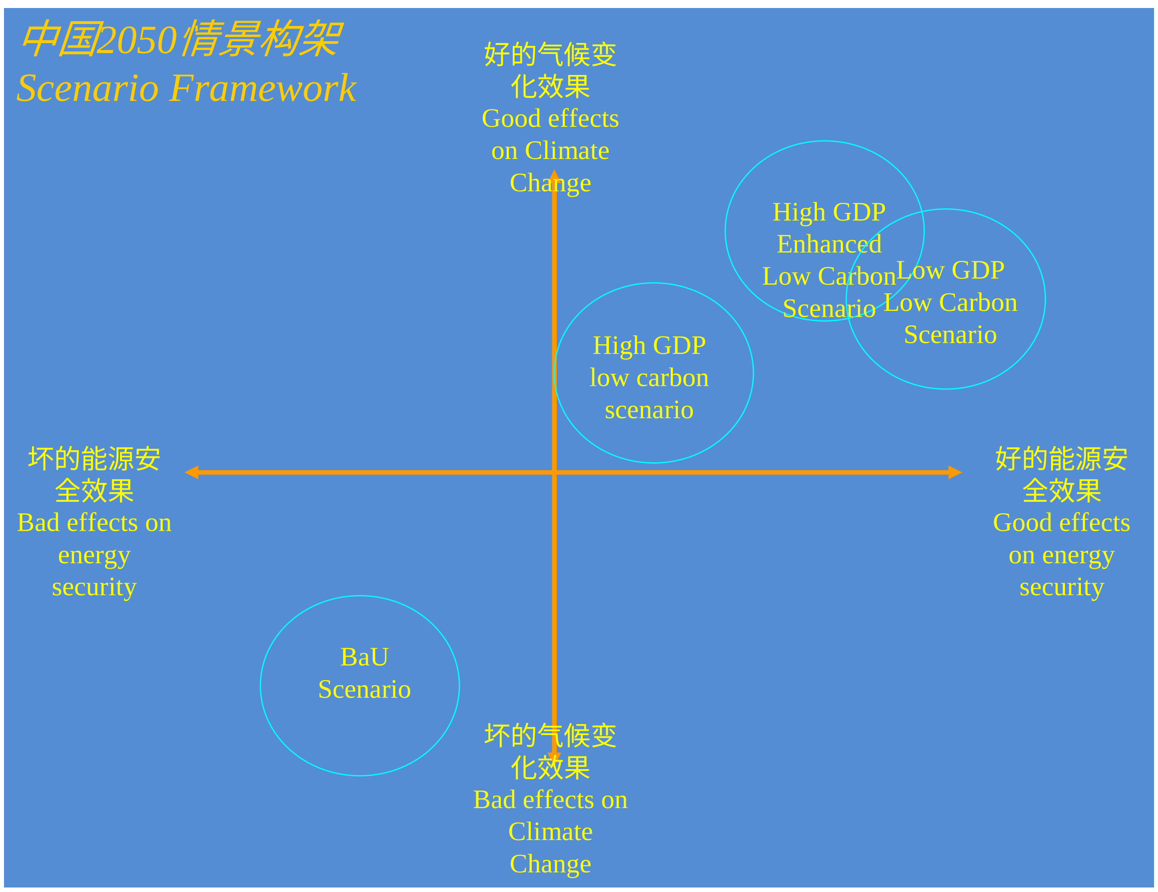
Low Carbon Scenario under high growth rate (HLC) This scenario considers factors such as sustainable development, energy security, and economic competitiveness. High energy saving standards, renewable energy and nuclear power generation developments, and carbon capture and storage (CCS) technology applied to a certain degree. Medium investment in low-carbon economy under the condition of full development of the Chinese economy.

Enhanced Low Carbon Scenario under high growth rate (HELC) Global mitigation of GHG emissions realizing a low GHG stabilization target. Main mitigation technologies are further developed, and have a faster decrease in cost. High investment in low-carbon technologies. CCS used to a much larger scale.

Low Carbon Scenario under low growth rate (LLC) The low carbon emission path that China can achieve, considering the requirements for low carbon development from China and the demand for global emission reduction

Figure 3 below shows the implications of climate change and energy security under different scenarios. Compared to the BAU scenario, Low Carbon under high growth (HLC) has positive benefits on not only climate and energy security.

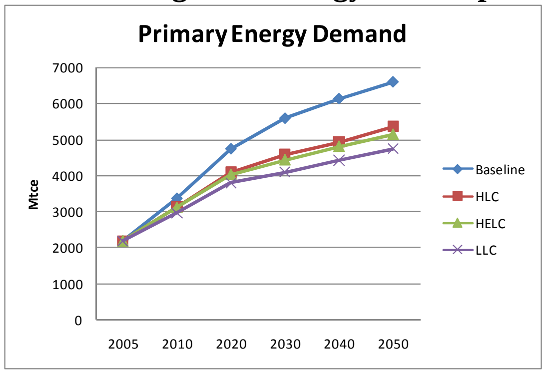
Figure 3 Implications of climate change and energy security under different scenarios



As can be seen in
Figure **4** below energy demand is expected to increase in all scenarios, due to the growth in the economy. However,

there is a significant difference of about 25% between the low growth low carbon and BAU scenarios. Changing the energy mix can have a significant impact on the emission profiles, with the enhanced low carbon scenario leading to missions about 50% lower than BAU. Importantly, the HELC scenario, with high levels of economic growth achieves the same levels of emissions cuts as the low economic growth model. This is because the higher economic growth enables low carbon technologies to be introduced at a faster pace.

Figure 4 Energy consumption and carbon emission under different scenarios



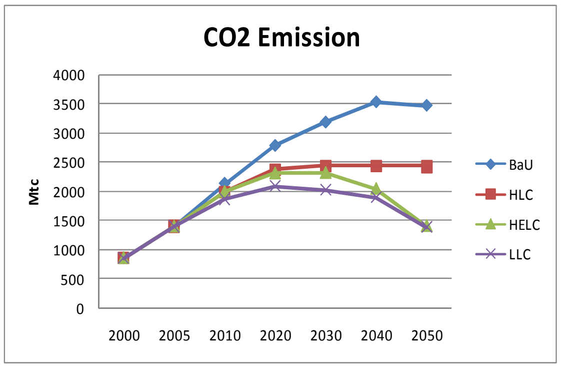


Table 3 Energy consumption and CO2 emission of different scenarios

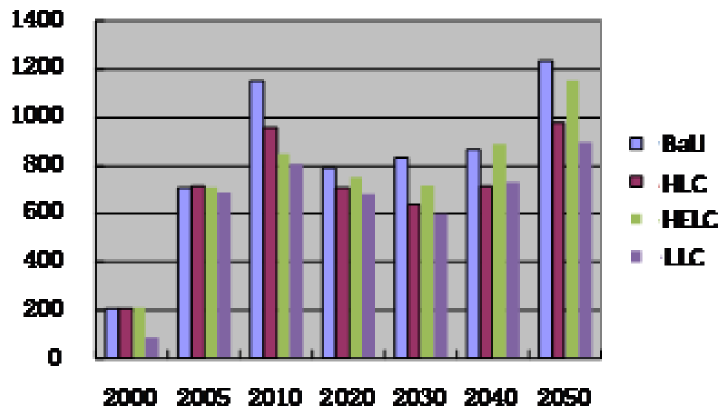
	energy consumption (Mtce)			CO2 emission (Mt)		
	BAU	Low carbon	Enhanced low carbon	BAU	Low carbon	Enhanced low carbon
2020	4820	4000	3920	10190	8290	8040
2030	5530	4470	4280	11660	8600	8170
2050	6660	5250	5010	12710	8820	5120

Table 4 Energy intensities of different scenarios

	2005-2020	2020-2030	2030-2040	2040-2050
BAU	3.5%	4.7%	3.2%	2.6%
Low carbon	4.2%	5.0%	3.6%	2.5%
Enhanced low carbon	4.4%	5.2%	3.5%	2.5%

In terms of the incremental investment, compared to the BaU scenario, more advanced technologies would be deployed in the low carbon scenario, with higher unit cost of investment in production capacity. But energy savings would more than offset this additional cost. This means that the total investment required is lower in the low carbon scenario than the reference scenario. In the enhanced low carbon scenario, with earlier large-scale deployment of advance technologies, the investment cost would be higher than the other two scenarios.

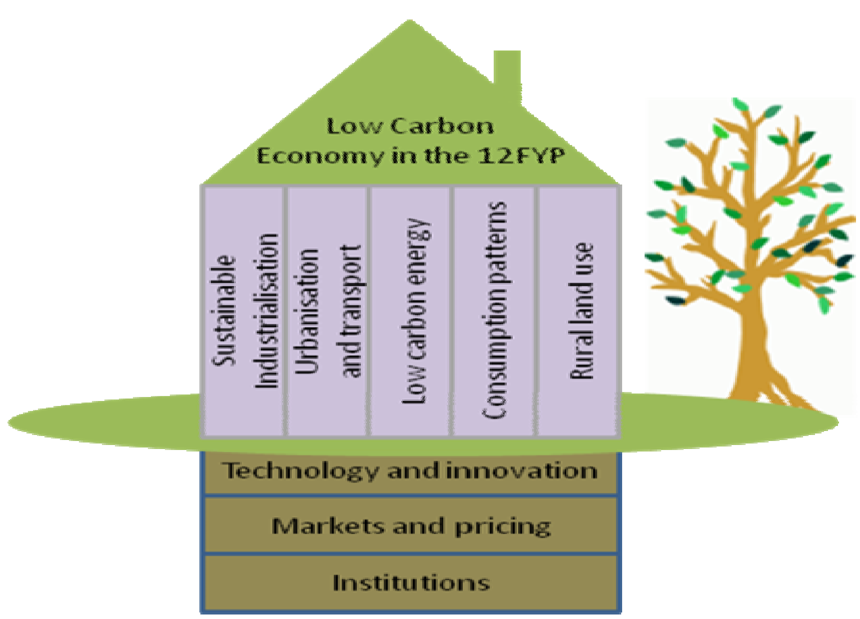
Figure 5 Investment needs in energy sector (billion Yuan)



5. Roadmap for China's low carbon development - based on five pillars and three bases

Based on the scenario analysis, this report outlines the roadmap for China's low carbon development. Figure 4 describes the basic framework, with five key pillars. These include: low carbon industrialisation; low carbon urbanization; sustainable consumption; low carbon energy and sustainable land use. These pillars are underpinned by three cross-cutting foundations, including technology and innovation; markets and pricing reforms; as well as institutional change.

Figure 6 Roadmap of China's low carbon development



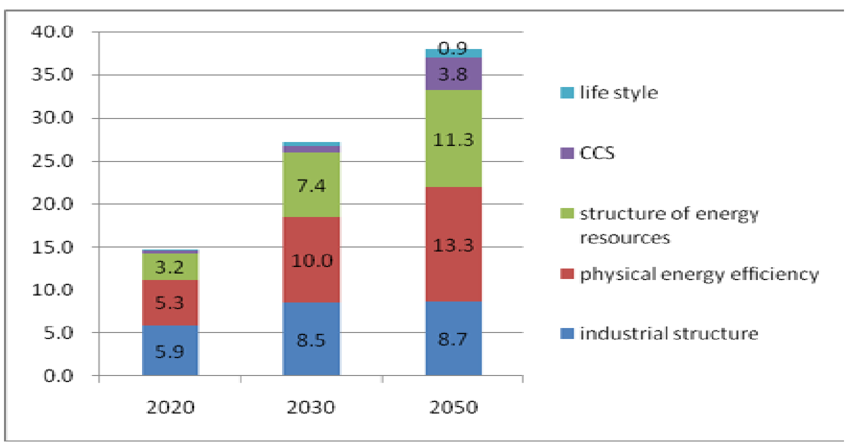
5.1 A major strategic choice and a low carbon vision for China

Scenario analysis shows that if China does not change its economic growth pattern, by the year 2030 its per capita CO_2 emissions will reach 8 tonnes per capita, while more than 80% of petroleum will be imported from foreign countries. But by taking a low carbon development pathway, China can reduce energy consumption in 2030 by 20% to 4.47 billion tonnes coal equivalent, and carbon dioxide per capita to 5.9 tonnes - based on domestic efforts to develop a low carbon economy. After 2030 the growth of GHG emissions slows down and remains broadly stable or even goes down.

Compared to the reference scenario, emissions reduction in the low carbon scenario will be driven by: 1) industrial restructuring; 2) efficiency gains in industrial end-use, transport, building and electrical efficiency; 3) life-style change, including transport modal shift; 4) improvements in energy sector, including higher efficiency of fossil fuel use and low carbon energy development; 5) use of CCS. As seen in Figure 7 industrial restructuring, efficiency gains as well as lifestyle changes will significantly contribute to carbon emissions reductions – 60% by 2020, 62% by 2030 and 57% by 2050. The development of new energy sources also makes a great impact – from 16% by 2020 to 24% by 20230 and 30% by 2050. Contributions from CCS will begin from 2030.

Figure 7 Contribution to emissions reduction under low carbon scenario

(Unit: 100 million tonne CO2)



The global shared desire to slow down climate change could have the effect of further strengthening technological advances and reducing the cost of key low carbon technologies more rapidly. Under these conditions, China could even further reduce energy consumption and GHG emissions. By 2050 carbon dioxide emissions decrease to 5.12 billion tons, lower than emissions in 2005.

If China achieves low carbon development in the process of industrialization and urbanization, its economic and social development would have the following characteristics:

- Industrial production is highly efficient, which means low emissions per unit of output.
- Energy conversion is highly efficient, which means low emissions per unit of electricity and distance travelled.
- Renewable energy sources and clean energy take a larger proportion of energy supply
- High energy efficiency and low emissions in transportation
- Domestic and commercial buildings are energy efficient
- Reduced export of products with high energy consumption and/or emissions

- Public transport replaces private transport; people use bicycles and feet more frequently.
- Industrial structure is optimized; low carbon industry has become a new focus of economic growth
- Agriculture, forestry and other land uses are managed to encourage carbon sequestration

5.2 Strategic objectives for China's development of low carbon economy

To realize the vision, four dimensions should be considered. Firstly, energy saving and energy efficiency enhancement should be vigorously promoted, in order to significantly reduce energy consumption per unit of GDP. Secondly, the energy structure should be optimized, so that the carbon emissions per unit of energy consumption will drop remarkably. Thirdly, carbon productivity can be substantially improved. In addition to energy efficiency and adjustments to the energy structure, optimizing land use management and increasing rural carbon sinks will make an important contribution here. Finally, China can lead the R&D and commercial applications of the world's low carbon technology, making low carbon industry a new source of economic growth and a new edge in national competitiveness.

According to analysis undertaken by the Task Force, these strategic goals can be quantified as follows:

- On energy intensity, the goal is to reduce energy consumption per unit of GDP by 75% -85% by the year 2050, which means an annual drop of 3-4%. The proportion of secondary industry should decline from the current nearly 50% to about 30% in 2050. China will strive to reach an internationally advanced level of physical energy efficiency by 2015 and reach an internationally leading level by 2030. Low carbon cities can be developed through a new model for urbanization and by establishing low carbon consumption patterns.

- Regarding energy structure optimization, China will strive to reduce carbon emissions factor per unit of energy consumption by 35-50% by 2050. By 2030, more than half of the newly increased energy demand will be met by low carbon energies; by 2050, the main increased energy demand will be met by clean energy. CCS will be gradually promoted and used since 2030.

- On carbon intensity, the goal is to reduce carbon emissions per unit of GDP by 85% to 90%. In other words, China's carbon productivity shall rise by 10 times, while carbon emissions per unit of GDP shall decrease by 4-5% annually.

- On improving carbon sinks, China will add 500-600 million tons of CO_2 to carbon sinks each year via afforestation, land management and other measures.

5.3 Five pillars for China's low carbon development

Pillar 1 - Low carbon industrialization

Optimizing and upgrading China's industrial structure. China will strive to increase the proportion of tertiary industry to make the modern service industry of knowledge, technology and management intensity. At the same time, across the industrial sectors, China will cultivate and develop emerging high-tech and energy-saving environmental industries. These will become two key drivers of economic growth.

In the medium and long term, the development and application of new technologies becomes the main focus of energy saving and emissions reduction efforts. The aim is to realize localized, independent innovation in key low carbon technologies.

Table 5 Projection of China's industrial structures (%) from scenario analysis

	2005	2010	2020	2030	2040	2050
Primary industry	12.4%	10.0%	6.7%	4.7%	3.6%	3.0%
Secondary industry	47.8%	49.0%	46.6%	42.9%	37.6%	33.4%
Tertiary industry	39.8%	40.9%	46.7%	52.5%	58.8%	63.7%

Table 6 Industrial efficiency standard - comparison to international level

	2000		2005		2007	
	China	BAT Int	China	BAT Int	China	BAT Int
Coal consumption for Power supply/gce/kWh	392	316	370	314	356	312
Steel /kgce/t	784	646	714	610	668	610
Aluminium/kWh	15480	14600	14680	14100	14488	14100
Cement /kgce/t	181	126	167	127	158	127
Ethylene/kgce/t	1125	714	1073	629	984	629

Source: Wang Qingyi, 2008 China Energy Data

Developing a circular economy with a high level of resource utilization, low energy consumption and emissions. In the near term China should: vigorously conduct resource-saving actions, in particular for construction materials like steel and cement; promote advanced and applicable technologies, process engineering and equipment to improve the recycling rate of mining, ore dressing and smelting; enhance the management of energy, raw materials, water and other resources in key industries; for waste generation, strengthen pollution prevention and control of the whole process to realize "zero emission" of waste; on renewable resource generation, vigorously reclaim and recycle various waste resources to support the re-manufacture of obsolete machinery and electronic products, and establish trash collection and sorting systems; establish systems and approaches towards a comprehensive, integrated product policy; and establish solid waste collection and classification systems.

Promoting more application of advanced and proven technology, and improving energy efficiency. The current efficiency of physical energy in China is 20-40% lower than that in developed countries. From a policy point of view, China must strengthen the monitoring of new projects and products, strictly implement and gradually improve energy efficiency standards; close down backward production facilities and encourage people to trade-in old low efficiency products for new ones; introduce advanced, efficient technology from foreign countries and proactively assimilate and adapt the introduced technologies. China should arrange R&D and demonstration of new generation of low carbon technology as soon as possible. Table 7 below is the blueprint for technological development in China.

Table 7 Blueprint of low carbon technology innovation and application

	Phase I (12 FYP)	Phase II (2010-2030)	Phase III (2030-2050)
Large-scale application	Current, proven, and advanced energy efficiency technology, energy saving building, solar thermal applications, combined heat and power generation, heat pump, ultra-supercritical boiler, wind power, second generation nuclear power, hybrid electric vehicles	Third nuclear power, wind power, next generation solar PV and concentrated Solar Power, electric vehicle, IGCC	Fourth nuclear power, CCS, solar electrical energy generation, second generation bio-fuel
R & D and promote commercialization	Third generation nuclear power, wind power advanced components, electric vehicle, IGCC, solar photovoltaic	Fourth generation nuclear power, CCS, second bio-fuel	Nucleosynthesis, third bio-fuel, advanced materials
Basic research	Fourth generation nuclear power, CCS, solar thermal generating, second generation bio-fuel, advanced materials	Nucleosynthesis, third bio-fuel, advanced materials	

Building a support system for low carbon technology innovation and strengthening the policy environment. Specific measures include: setting up the special institute for promoting low carbon technology innovation; building a common platform of technology innovation or establishing a new alliance for technology innovation; promoting group development of universities, R & D institutes and enterprise R & D, promoting information exchange. Furthermore, policy development for technology innovation should be sped up, including accelerating financial support for basic R & D; supporting demonstration by providing government funding, tax reduction, preferential loans and temporary prices; and to encourage commercialization, setting a price for carbon, solving the imbalance of new technology information, granting franchise rights, government procurement and improving regulatory standards and implementation.

Pillar 2 - Building low carbon cities - a new approach to urbanization in China

According to the experiences of OECD and EU countries, the energy utilized in urban buildings and transport accounts for two thirds of final energy consumption. The share also grew rapidly in China from 35.9% in 2000 to 41.9% in 2007. Given the pace of urbanization, avoiding building sector lock-in is critical for China's low carbon development. China should optimize the spatial arrangement and improve the energy efficiency of basic infrastructure to develop a low carbon city as soon as possible. Specifically, it should:

Advocate compact urbanization. Research shows a negative correlation between the urban population density and urban energy consumption per capita. China should draw lessons from urbanization models from other countries and develop a compact urbanization pathway that is applicable to China's predicament, This could be achieved through keeping to a certain level of urban density; developing city groups and belts based on mega-cities and city centres; and identifying an urbanization strategy based on large-scale cities and the concept of compact cities.

Vigorously develop public transport system and optimize urban transportation structure. Specific policies include: (1) Promote urban public transport to increase the modal share of public transport and curb the growth rate of private cars. (2) Accelerate the development of intra-city railways and inter-city expressways to form three-dimensional transport systems; cities of population 2 million and above may consider intra-city railway transport. (3) Continuously elevate mandatory fuel efficiency standards of motor vehicles, and vigorously develop low carbon vehicles such as hybrid and electric vehicles.

Strengthen the promotion of energy-saving building technology and standards and develop low carbon urban buildings. Specific policies include: (1) Introduce building energy efficiency standards and labeling systems, improve building energy saving standards, and improve enforcement and monitoring; (2) Strengthen energy conservation initiatives for existing energy inefficient buildings, encourage energy service companies to improve existing public buildings; (3) Support R&D of important energy saving building materials and commercialization; (4) Provide incentives to developers and consumers to invest in and purchase energy-conserving, low-carbon buildings, provide tax breaks to buyers of energy-conserving, low-carbon homes; (5) Demonstration of energy-conserving, low-carbon buildings.

Improve urban energy supply modes and increase the utilization of new energies. First, encourage the development of distributed energy sources such as combined heat and power (CHP) generation, which has an integrated energy efficiency of 70%-80%. CHP has been an important measure for the Nordic countries to improve energy efficiency. However, in northern cities of China, CHP generation accounts only about 20% among urban heating. Combined heat, power, and cooling (CHPC) should be vigorously promoted in northern China to increase the urban energy supply efficiency. Second, advance the reform in district heating system, implement household based heating metering to provide incentives for personal energy saving. Third, improve the rate of electrification and the rate of urban gas utilization to increase the proportion of high quality clean energies.

Strengthen urban energy management and carry out energy saving product certification. The electric power consumption of large scale public buildings is equal to the total electric power consumption of urban residential buildings, but is only 5% of the total building area; if the refrigerating appliances, electric machines and electric equipment in those large scale public buildings are revamped, 30%-50% energy can be saved. There should be a supervisory system for energy consumption of large commercial buildings, energy auditing and reform demonstration and energy saving operation management demonstration. China can enlarge the range of certified energy saving products, and explore the establishment of an internationally recognized system for certified products as well as improving consumer awareness of certified products.

Pillar 3 – optimizing China's energy structure, and developing more low carbon energy

About 90% of greenhouse gas emissions in China come from the burning of fossil fuels. Therefore, optimizing the energy structure and developing more low carbon energy are highly important - helping to reduce the GHG emissions per unit of energy consumption. Under the low carbon scenario, the energy sector will reduce CO_2 emissions by in 2020, 2030 and 2050 by 380 million tons, 830 million tons and 1.59 billion tons respectively, contributing a share of 20.3%, 27.3% and 40.9% in terms of total reductions. With the deployment of CCS, further reductions from the energy can be achieved: an additional 100 and 380 million tons of CO2 reduction in 2030 and 2050 respectively.

To realize this potential, it is critical to gradually reduce the share of coal in energy consumption, speed up the development of natural gas and guarantee the security of oil supplies, and to actively develop the utilization of hydropower, nuclear power and renewable energy sources. By 2020, these alternative energy sources will be increased significantly. By 2030, clean energy can meet more than half requirements of new added energy. In 2050, clean energy can meet most of requirements of new added energy. At the same time, an infrastructure system suited to the development of renewable energy sources such as a smart electric grid will be built. The specific approaches are as follows:

Intensive and effective use of coal. The first step is to control the rate of growth of coal. By 2020, coal growth will have reached its peak and the share of coal in energy consumption will be reduced from about 70% at present to about 55%, then to below 50% in 2030, and to about 33% in 2050. Secondly, advanced coal-fired power generation technology will increase efficiency. In 2020, the aim should be to reduce coal consumption in power generation to 320 g/kWh; new thermal power units will mainly adopt ultra-supercritical generating technology and IGCC. By 2030, with a reduction of coal consumption of power generation to 290 g/kWh, the proportion of IGCC plant in additional plant will increase to 50%. By 2050, coal consumption in power generation will be reduced to 270 g/kWh. Thirdly, poly-generation technology such as combined heat and power and cold cogeneration will be vigorously promoted to increase comprehensive utility efficiency. In 2020 and after 2030, the goal is to increase the efficiency of transforming coal to electricity from the current level of 55% to 65% and 80% respectively.

Switching to lower carbon fuels. Great efforts should be made to develop energy-saving and low carbon transport such as electric vehicles; sustainable bio-fuels and the development of public transport. China should strive to limit the amount of petroleum consumption to within 550 million tons in 2020 and within 700 million tons in 2030. By expanding the development and use of domestic natural resources and by importing natural gas and LNG from surrounding countries, natural gas can replace a significant amount of coal and petroleum in China. By 2020, 2030 and 2050, the goal is for the proportion of natural gas consumption in primary energy consumption to reach about 8%, 12% and 14% respectively.

Large-scale deployment of low carbon energy. China should speed up the construction of hydropower, nuclear power, and wind-power and promote commercialization of solar power by 2020. Low carbon power generation capacity will reach about 550 million KW, accounting for 35% of total installed capacity. Low carbon energy utilization will reach 800-900 million tons standard coal equivalent, equivalent to 20% of energy consumption. 50% of installed capacity will be low carbon by 2030 and, by 2050, all new installed capacity will be low carbon. Globally, the proportion of low carbon energy supplies will exceed one third by this time and China's energy will be cleaner and more diverse: coal 33%, oil/gas 33% and low carbon energy sources 33%.

Table 8 International comparison of China's low carbon energy targets for 2020

	Proportion of low carbon energy in energy consumption 2020	Proportion of low carbon power generation in total installed capacity
China	20%	35%
America	20% renewable energy plus approximately 15% nuclear	N/A
United Kingdom	15% renewable energy plus approximately 5-10% nuclear electricity	30-50 GW of renewables, 1-5 GW of nuclear from a total installed capacity of 100-120 GW
European Union	20% renewable energy and approximately 30% nuclear electricity	Approximately 350-400 GW of renewables, 100 GW of nuclear from a total installed capacity of 1000 GW

* In North America and Europe, there are no targets for the use of energy, therefore the figures are based on trend analyses.

Building a strong, smart grid. As the proportion of low carbon energy grows, additional demands will be placed on infrastructure and grid management. In response, China should construct a strong grid framework and enable transmission of electricity from new sources such as wind and nuclear power. Secondly, the ability of the distribution network to manage variability of supply and demand should be improved, and supported with demand side management, including in future from electric vehicles. Local renewable energy should be promoted.

I**mplementing carbon capture and storage** in stages and in a focused manner. Before 2020, China should focus on research and development and experiment and demonstration, and can also undertake some low cost carbon capture and storage by integrating with petroleum exploitation. Later, China's IGCC plant and some industrial processes are expected to employ CCS.

Pillar 4 – Sustainable consumption patterns

Low carbon consumption is an important part of the low carbon economic system. Japan and the United States are broadly at the same level of development, yet Japanese energy demand is 4 tonnes of standard oil equivalent per capita, while the US is 10 tonnes per capita. Analysis shows that 70% of the Japan-USA energy consumption gap lies in different patterns of consumption. Low carbon consumption - an extension of the sustainable consumption concept - is described in China by the "6R" principles:

1) Reduce: save resources, reduce pollution;
2) Re-evaluate: green consumption, environmental protection;
3) Reuse: reuse, multiple use;
4) Recycle: garbage classification, recycling;
5) Rescue: rescue species, protect nature;
6) Re-calculate: consumers consider the "carbon footprint".

Consumers should be encouraged to choose products and lifestyles with small carbon footprints. To build a low carbon consumption pattern, several aspects should be promoted – including through culture, policy, concept, principle, habit, behavior and evaluation. The details are as follows:

Strengthening institutional framework: The "Sustainable Consumption Act" and "Green Procurement Act" should be enacted in the near term. Accelerate research on carbon emission standards on the consumption side. In the medium and long term, "Solid Waste Disposal Act" should be stipulated and consumption side carbon emission standard should be enacted and improved.

Increasing tax and fiscal stimuli: Fiscal support for consumers of green products will be increased in the short term. Subsidies will be provided for products that use electricity efficiently, new energy automobiles, etc. Green consumption credit will be studied. In the medium and medium to long term, carbon emission tax and environmental tax will be designed and implemented, and the proportion of green consumption credit will be increased. In the long term, combination with wider tax reform is necessary to realize transition to a nationwide green tax system.

Intensifying public education: A national public awareness plan and education activities will be explored in the near term, which includes community and company awareness raising and school education. Family based education will be encouraged, and citizen awareness of green consumption will be improved. In the medium and long term, a national Merit Award Scheme will be implemented (awards such as "Green Enterprise", "Green Community", "Green Household" and "Green School"). The publicity should cover both urban and rural areas, reaching all citizens. China will develop a social norm of low carbon consumption behavior.

Establishing a system for green information sharing and monitoring mechanism: in the near term China will establish a publicity information system related to law, standards, administrative proceedings, technology and products. In the medium and long term, it should promote a "carbon footprint" calculating formula for the whole society, designed and suited to China's conditions. In the long term, using information technology, we will build real time information and monitoring mechanisms to reveal carbon emissions.

Pillar 5 - Land use management and carbon sinks

In recent years, the amount of carbon stored in China's terrestrial ecosystems has increased by 190-260 million tons annually. This is equivalent to around 28%-37% of the total amount of carbon dioxide emitted by industry in China.

Carbon sequestration is therefore an important dimension to the low carbon economy. Three key land use types are forests, arable land and grassland. In each case, three dimensions should be considered: increasing the amount of carbon stored, protecting existing carbon storage; and offsetting emissions from other sectors.

Increasing carbon sequestration in forests. Forests are an important store of carbon in China. In recent years the amount has grown by 150 million tons of carbon annually. In order to increase sequestration in forests, China should take the following measures: recovery of degraded ecosystems, establishing an agriculture-forestry system, strengthening forest management to improve the production of forest, prolonging rotation time; reducing deforestation, improving logging regulations, improving logging utilization efficiency, effectively controlling forest disasters (forest fires, plant diseases and insect pests); using marsh gas instead of fuel wood and durable lignin products instead of energy intensive materials, recycling logging residue and further processing of wood products via recycling.

Increasing carbon sequestration in arable land. Arable soil makes an important contribution to the total carbon sequestration in terrestrial ecosystems as well as the most active sink. The organic carbon content of China's arable land is relatively low in general, about 0.8%～1.2% in South, 0.5%～0.8% in North China, 1.0%～1.5% in northeast and below 0.5% in most areas of the northwest. The organic carbon content of most European arable lands exceeds 1.5% and in the US it reaches 2.5% to 4%. Therefore, China has a great potential to increase the carbon storage of arable land.

Retaining and increasing carbon sequestration in grassland. The key to retaining and increasing carbon sequestration in grassland lies in preventing degeneration and exploitation. Specific measures include reducing grazing density, enclosing grassland, planting new areas and restoration of degraded grassland. In addition, grassland sequestration can be improved by animal husbandry management approaches such as fence breeding, rotational grazing and by introducing different grass varieties.

Table 9 Main measures to increase carbon sequestration

Land type	Carbon sequestration	Retaining carbon stocks	Substitution
Forest	• Forestation and reforestation • Forest fertilizer • Prolong rotation time	• Reduce cutting • Prevent intensive agriculture and grazing and disforestation • Fire management • Plant diseases and insect pests management	• Other biological energy source instead of fuel wood • further processing of wood products • Prolong useful time of wood product • Recycling of wood product and paper • Develop replacement industry
Arable land	• Returning strew to arable land • Fertilizer management • Zero tillage • Returning land for farming to forestry and grassland • Recovery of degenerated soil • Using organic fertilizer	• Prevention soil degradation • Fertilizing management • Water management • Vegetation conservation	• Develop bio-fuel • Develop replacement industry
Grassland	• Artificial forest, plant grass • Recovery of grassland • Fertilizing and irrigating grassland	• Prevention overgrazing • Closing grassland	• Taking reasonable animal husbandry management measures • Develop replacement industry

6 Policy recommendations

This report offers eight specific recommendations:

1) Start the development of a low carbon economy as early as possible, incorporate the concept into the 12th Five Year Plan, and introduce CO2 emission intensity as a binding target in the Plan.
2) Reform energy pricing to reflect market demand and supply, resource shortages and environmental costs
3) Build a green tax system and increase fiscal expenditure for the development of the low carbon economy.
4) Using market mechanisms to promote low carbon development.
5) Aggressive support for technological innovation, diffusion and international cooperation
6) Improve legislation and regulations, and strengthen enforcement of laws and standards.
7) Improving the quality of energy and carbon statistics and measurement
8) Include the requirements of the low carbon economy in urban planning, and run demonstration projects.

6.1 Start the development of a low carbon economy as early as possible, incorporate the concept into the 12th Five Year Plan, and introduce CO2 emission intensity as a binding target in the Plan

Earlier transition to a low carbon economy is better than a later transition. Strategic deployment of low carbon development should be launched as soon as possible. The first recommendation of the Task Force is the inclusion of Low Carbon Economy as a key principal in the 12th Five Year Socio-Economic Development Plan.

a) **In the 12th Five Year Plan, set targets for reduction of carbon emissions per GDP unit.** According to preliminary calculations, during the 12th Five Year Plan period energy consumption per unit of GDP could be reduced by about 15-17% through energy saving measures, while the development of new energy sources could reduce carbon emissions per unit of GDP by 5-6%; thus energy-saving measures and new energy sources combined could reduce carbon emissions per unit of GDP by 20-23% or greater. Therefore we suggest that a 20% reduction in carbon emissions per unit of GDP is set as one of the binding targets of the 12th Five Year Plan.

b) **In the 12th Five-Year Plan or its programmes for implementation, identify the main methods and sectors through which the low carbon economy will be developed.** At the same time, disaggregate low carbon economy targets and tasks to regional and sectoral level, and increase enthusiasm for development of new energy.

c) Include low carbon industrial development and technological innovation as important parts of the **12th Five-Year Plan's programme for structural adjustments and technological innovation**. Promote low carbon innovation and industrial innovation via project construction, industrial development, technological innovation and systems and mechanisms.

6.2 Reform energy pricing to reflect market demand and supply, resource

shortages and environmental costs

Reform of energy pricing is a key lever for meeting low carbon objectives. Three areas have been identified: First, gradually realise competitive price setting in the energy sector, with clear supervision of natural monopolies. Second, reflect the external costs and resource consumption of energy development, processing and use in the price of energy products. Third, cross-subsidies should be made transparent and later be eliminated, with any subsidies for energy consumption being provided from public finances. Specifically:

Coal: The cost calculation policy should be reformed, with fees for use of coal reserves, safe production, environmental restoration, transfer of coal mines and employee health costs fed into the cost of coal, thus internalising external costs and gradually realizing coal pricing which reflects total costs.

Electricity: The price of conventionally generated electricity (such as from coal) at the point of supply to the grid should be gradually allowed to be set by the market. The cost of distributed electricity should gradually become independent. The issue of cross-subsidy of retail electricity costs should be gradually resolved, in order to provide a foundation for bilateral electricity trading. In the near future the extra costs associated with renewable and clean energy will need to be promptly apportioned as these sources expand.

Oil and natural gas: Further reform the pricing of oil products. Recently the government has set retail costs in accordance with international prices. In the mid- to long-term, the wholesale markets should be liberalised in order to create a competitively priced market. The factory-gate cost of natural gas should gradually shift from government-set to market-set, while achieving a more rational price via adjustment of resource taxes.

District heating: Centralised heating provision and more efficient combined heating-cooling projects should be promoted and encouraged. Heating and cooling use should be measured by household, and pricing reformed. Reform of heating subsidies should take place as soon as possible, with hidden subsidies becoming visible, and a “pay for what you use” system implemented. Heating should become a monetised commodity, with a rational price setting mechanism.

6.3 Build a green tax system and increase fiscal expenditure for the development of the low carbon economy.

Incorporate costs of environmental damage and resources depletion in energy pricing through adjusting taxes and fees during early resource exploration. This includes: raising fees made for release of pollution; increasing the scope of collection of fees; gradually replacing pollution fees with pollution taxes; and ensuring the “polluter pays”. Resource taxes should be collected as a percentage of the market price - not as a fixed amount for a given quantity of the resource. Export tax rebates for energy-intensive products should be reduced, or extra tariffs could even be imposed, in order to reduce the export of energy in this form.

Guide consumption and behavior through an energy tax to increase costs.
In China, petrol and diesel already incur taxes of 1 RMB and 0.8 RMB per litre respectively. We suggest that at an

appropriate time this is increased, and other energy taxes introduced.

Preparations for a carbon tax should start soon in order to send a stable price signal for low carbon innovation and large-scale commercialisation. It should not be set too high at the onset, but as the economy further develops and societal acceptance deepens it should be adjusted upwards.

Strengthen fiscal support for energy saving, renewable energy and low carbon technological innovation, including:

i) Energy-saving: Regular budgets should include an outlay for energy-saving; energy-saving products and companies should receive tax breaks and direct subsidies; and energy-saving should be given greater weight in government procurement.

ii) Promotion of renewable energy: Further reduce value-added tax for renewable energy; implement business tax reductions for the sector; reduce import tariffs and value-added taxes on renewable energy equipment; offer subsidies for households purchasing solar roofing or small wind power generators.

iii) Promote technological innovation: Increase investment in low carbon research and development; provide tax breaks for enterprises carrying out low carbon research-and-development and technological innovation.

iv) Increase funding channels: In the near future, existing government funds should be reorganized and standardised, with orientation shifting from construction funds to funds for sustainable development of energy, focusing on energy-saving, renewable energy development and technological innovation. In the mid- to long-term, part of the revenue from additional fuel, energy and carbon taxes can be allocated to sustainable development funds.

6.4 Using market mechanisms to promote low carbon development.

In addition to using carbon tax to determine the price for carbon, China should use market mechanisms to encourage low cost carbon abatement.

In the long term China should establish a carbon trading scheme. In the near term, a voluntary carbon trading scheme would help build capacity and accounting systems. Appropriate subsidies or loan support should be used to encourage firms to carry out voluntary emissions reductions, with participating firms proposing emissions reduction against their baseline emissions, with the government organising emissions trading among the companies. Companies could register at the existing environmental asset exchanges, allowing the trading, settlement and auditing platforms there to be used, establishing emissions auditing, reporting and operating methods. At the same time, third-party certification agencies would confirm emissions baselines and reductions, with confirmed surplus emissions rights and those already confirmed by international authorities traded at the exchange.

Within a global framework to reduce carbon emissions, China should make use of international financing mechanisms. This is not only about attracting carbon finance but making use of the mechanisms like the Clean Development Mechanism (CDM) to encourage the deployment of energy savings technologies. In addition, China can gradually introduce a carbon banking system, establishing carbon accounts for regional and major enterprises.

6.5 Aggressive support for technological innovation, diffusion and international cooperation

a) **Strengthen the construction of public research-and-development institutions and testing platforms.** These will have a hugely important role in systems supporting technological innovation. They will be particularly crucial in the research and development of framework and common technology, promoting commercialisation and carrying out major government research programs. **We propose establishing a new, open national energy research institution.** This will have not just the ability and facilities to carry out research; it will also be able to carry out pilot projects, hence covering basic research, development, trials and testing and certification. The institution will be open to businesses, universities and other research institutions, and will carry out research and development of basic and common technology, experiments, testing and certification. This will resolve the lack of adequate common technology in the new energy sector.

b) **Further improve policies encouraging technological innovation.** First, continue to implement the extremely important policies on self-reliance programs and requirements for equipment in major projects to be sourced domestically, to promote localisation. Second, as soon as possible, implement detailed rules for implementation of the plans for adjustment and reinvigoration of the equipment manufacturing industry, establish and use risk compensation mechanisms for new domestically produced equipment, and encourage insurance companies to insure these projects. Implement preferential tax policies for technological innovation. Also, fund and encourage firms to form alliances to research common technologies and the domestic production of key components.

c) **Seek technology cooperation opportunities along the innovation chain from research to piloting and finally large scale commercialization. This includes support for large-scale demonstration, as well as tax incentives and subsidies for purchases of low carbon products.**

6.6 Improve legislation and regulations, and strengthen enforcement of laws and standards.

a) **Improve legislation of energy production and transfer, energy-saving, solid waste and forestry sectors to help reduce carbon emissions.** Specifically: As quickly as possible produce and implement the *Energy Law*, and make revisions to the *Coal Law*, *Electricity Law*, *Energy Saving Law* and *Renewable Energy Law* that will further encourage the development and use of clean, low carbon energy sources. Produce and improve regulations on implementation of the *Law on Promotion of the Circular Economy*. Establish systems of regulations based on the *Agriculture Law*, *Forestry Law*, *Grasslands Law* and *Land Management Law* that will improve agricultural and forestry production, and increase the carbon storage of their ecosystems. Revise regulations on protection of forests, farmland and grasslands, and strictly control development in environmentally vulnerable regions. Strengthen policies to prevent the destruction of natural forest, grasslands and farmland.

b) **Draft and improve energy standards.** Improve design norms for energy-saving in the main energy-consuming industries and building energy saving standards, and improve standards for controlling heating and cooling of buildings. Draft energy-efficiency standards for energy-consuming industrial equipment such as fans, pumps, transformers and engines; as well as for domestic appliances, lighting, office equipment and vehicles. China could also consider adopting a system like Japan's Top Runner programme – using the most efficient model on the market and then stipulating that the efficiency of this top runner model should become the standard within a certain number of years.

c) Strengthen enforcement of energy-efficiency standards. Energy-efficiency standards should be included in the evaluation and auditing of industrial projects. New or expanded fixed-assets projects should be subject to carbon-emission reduction evaluations and auditing, with approval refused for those that do not carry out, or fail, evaluations – thus reducing emissions at source. Energy efficiency tests should be carried out for all major public buildings and commercial residential housing, with completion procedures denied to those failing to pass.

d) Improve 'carbon footprint' labeling and certification. Gradually implement a "carbon footprint" labelling system, and steadily expand the scope of the scheme. Increase public awareness to shift consumption to low carbon products and therefore encourage firms to develop those products.

6.7 Improving the quality of energy and carbon statistics and measurement

a) Improve energy statistics and systems. Improve energy survey and auditing methods to increase the scientific nature of statistics gathered. Strengthen and standardise energy statistics activity at the grassroots level, to increase accuracy. Also, establish statistics agencies below the city level to strengthen the foundation of statistics gathering.

b) Establish a carbon footprint measuring system. The first step is, on the foundation of energy-saving and emissions-reduction work, verify the emissions of energy and emission intensive products and equipment in key industries. Encourage other businesses to calculate their greenhouse-gas emissions according to international standards – either doing so themselves, or employing a third party to do so. This information will inform clear carbon emissions standards and carbon emissions reduction targets for both industries and products. At the same time, the authorities should organize experts to research methods of calculating carbon footprints and labeling standards. A supervision and certification authority should be formed. The measuring of carbon footprints should be included in the Statistics Law. Appropriate monitoring and certification bodies should be set up to determine the criteria as well as to encourage the acquisition of metering equipment, training of personnel, and monitoring mechanisms. In future, the Statistics Bureau should begin to collect carbon emissions data and make relevant data publicly available on a regular basis. In addition, industrial associations should be encouraged to monitor the rate of technology innovation, and use of lower carbon technologies.

6.8 Include the requirements of the low carbon economy in urban planning, and run demonstration projects.

a) Include requirements for "low emissions, high efficiency" in urban planning and rural development

planning. Propose and improve low carbon urban planning strategy, exploring low carbon urban planning in terms of urban zoning, industrial structure, public transport and land use.

b) Start a batch of low carbon urban development projects in suitable cities in the near future. Survey and analyse energy use of aspects such as transport and buildings; then use economic incentives, policy and systems, technological innovation and application, and public funding to achieve energy-savings, ultimately reducing urban carbon emissions. In the near term, new cities should include low or zero-carbon communities, industrial zones or ecological cities. Common standards for measuring low carbon development should be developed and agreed, reflecting the diversity of development characteristics

c) Low carbon development should be taken into consideration when choosing winners of national ecological, environmental and liveable city competitions. Change the current situation in which environmental cities are environmentally friendly in some aspects, but overall still have high carbon emissions.

d) The rural dimensions of China's future low carbon economy should not be overlooked. Land use management and change has a significant effect on the amount of carbon stored in terrestrial ecosystems. Sustainable approaches to agriculture, forestry and bioenergy can make a significant impact on greenhouse gas emissions, creating important opportunities for carbon finance in rural areas. Urban-rural economic and transport linkages affect the pattern of energy and greenhouse gas emissions, and many industries are located in rural areas. China is already seeking to achieve balanced urban-rural development. The low carbon economy can make a major contribution to this objective.

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Notes

[1] "Low Carbon" is shorthand for "low greenhouse gas" – while CO_2 is the main contributor to global warming, the role other greenhouse gases must not be overlooked.

[2] McKinsey & Co "Pathways to a Low Carbon Economy: Version 2 of the Global GHG Abatement Cost Curve"

[3] McKinsey Global Institute, 2008. The Carbon Productivity Challenge: Curbing Climate Change and Sustaining Economic Growth

[4] Stern Review "The Economics of Climate Change" (table 10.1)

[5] Guiyang Zhuang, *Low Carbon Economy: No Alternatives Left for China*, Chinese Academy of Social Science, May, 2007

[6] HM Treasury, *Stern Review: The Economics of Climate Change*, Executive Summary, 2006

[7] IEA (2008), *Energy Technology Perspectives 2008,* International Energy Agency

[8] European Renewable Energy Council, Greenpeace International, Working for the Climate, Renewables Energy and the Green Job Revolution, August 2009

[9] Daniel Wallis, 'Disasters losses may top $1 trillion/yr by 2040-UN', *Reuters*, 14 November 2006

[10] Ministry of Civil Affairs in Ningxia. See: Li Yue, Wu Yanjuan, Conway, D., Preston, F., Lin Erda, Zhang Jisheng, Wang Taoming, Jia Yi, Gao Qingzhu, Shifeng, Ju Hui (2008) Climate and Livelihoods in Rural Ningxia: Final Report. AEA Group. 26pp. www.china-climate-adapt.org

[11] Unruh, G.C. 2000 "Understanding carbon lock-in" *Energy Policy* ***28*** *p817-830*

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