Centre for Climate Change Economics and Policy

Grantham Research Institute on Climate Change and the Environment

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**Policy paper**

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# China's growth, China's cities, and the new global low-carbon industrial revolution

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**Abstract**

Unless the world embarks now on a new energy and industrial revolution it will be very difficult to manage the huge risks of climate change. Business-as-usual for the next few decades will bring a significant chance of global temperatures not seen on the planet for tens of millions of years, long before *homo sapiens* appeared, with great risks of migration of hundreds of millions of people and extended and severe conflict. However, the new industrial revolution and the transition to low-carbon growth constitute a very attractive path. It is likely to bring 2 or 3 decades of innovative and creative growth and large and growing markets for the pioneers. Low-carbon growth, when achieved, will be more energy-secure, cleaner, safer and more bio-diverse than its predecessors.

Cities around the world are responsible for around two-thirds or more of both energy and greenhouse gas emissions. The choices that are made about transport, infrastructure, building, and industry in cities, as they grow rapidly in the next two decades, will determine, via the technology and ways of life they lock-in, whether mankind can both manage climate change and draw the benefits of the new patterns of growth. The challenge for the world as a whole is to cut global emissions by at least 60% between now and 2050 whilst maintaining or enhancing growth and overcoming poverty. Cities will be at the centre of this story.

China's development as the world's fastest-growing large economy, with very rapid urbanisation, will be at the heart of these developments; low-carbon growth in China is vital for the world as a whole and for China's own future. China is already at the forefront of the development of new low-carbon technologies and China has a great deal to gain by being in the vanguard of this new global growth story. The urgency, the scale of the required changes, and the magnitude of the opportunities in the new economy, mean that green policies should be at the core of the next few five-year plans. We already know, from the plan outline published earlier this month, that the low-carbon economy is a central priority in the 12$^{th}$ five-year plan.

**China's growth, China's cities, and the new global low-carbon industrial revolution**

**Policy Paper to Accompany Keynote Address to the Plenary Session of the Summit Forum at the Closing of Shanghai Expo 2010**

It was a great honour to be invited to the Shanghai Expo, in one of the truly great cities of the world. I first visited Shanghai in 1988 when I was teaching in the People's University of China, where I am still an honorary professor. Pudong was rice fields and there were no tunnels or bridges across the river. Now Pudong is a dynamic modern city and there are seven bridges and nine tunnels. Shanghai and China have shown how a city, economy and society can be transformed in two decades.

I have visited China many times in the last 22 years and I am a great admirer and I hope a loyal friend. China has lifted hundreds of millions out of poverty. This has been the most dramatic example of development in human history. But unmanaged climate change would likely halt and reverse the great advances in development that have occurred over the last few decades. These advances have, around the world, allowed many hundreds of millions to rise out of income poverty, great improvements in health and life expectancy, and major progress in education and literacy. The two defining challenges of our century are managing climate change and overcoming world poverty. If we fail on one we will fail on the other.

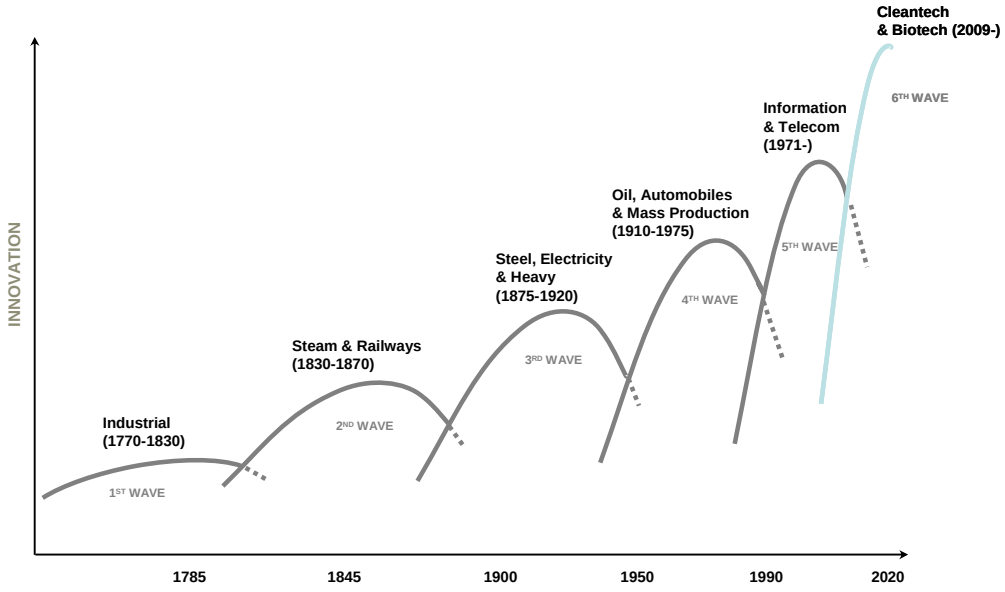
'Business as usual' (BAU) for the next few decades will bring grave risks. Greenhouse gas concentrations (or stocks) have increased to around 435 parts per million (ppm) of carbon-dioxide-equivalent ($CO_2e$). If we continued with BAU for a century we would add at least 300 ppm, taking concentrations to around 750 ppm $CO_2e$ or higher around the end of this century. That would likely lead to around a 50% chance of warming by $5^oC$ compared with pre-industrial temperatures.[1] A rise of $5^oC$ is immense: it would mean average temperatures that the planet has not seen for more than 30 million years. *Homo sapiens* has experienced nothing like this, being present for only around 200,000 years. Such warming would cause disruption on a huge scale to local habitats and climates, for example through flooding, desertification, and water scarcity. Hundreds of millions of people would have to move, with the associated

[1] Source: Stern N., 2009, A Blueprint for a Safer Planet: How to Manage Climate Change and Create a New Era of Progress and Prosperity, Bodley Head.

risks of severe and extended conflict. China is especially vulnerable with its large fraction of the population near the coast, its pressures on water supply, its dependence on the Himalayan region as a water source, and the location of so many populous countries along its borders.

But this is a story of opportunity as well as the management of risk. The transition to low-carbon growth in the world economy will constitute a new industrial revolution: by 2050 most of the major sectors of the economy must be close to zero carbon if we are to have a reasonable chance of holding temperature increases to 2°C. We have seen five industrial revolutions, or waves of technical change, as illustrated in Figure 1: the first at the end of the 18th century with the mechanisation of textiles and the fifth, which continues, in information and communications technology.

Figure 1: Waves of innovation[2]




These experiences suggest that the next two or three decades are likely to bring dynamic, innovative and creative growth, and large and growing markets and opportunities for the pioneers. There are already exciting developments along the way. For example: it may soon be possible to artificially create bacteria that produce biofuels and soak up $CO_2$ from the atmosphere; high-capacity nano-batteries; solar cells printed on aluminium foil with high efficiency and lower costs. And the list grows: ideas are appearing at an astonishing pace. Not all will work, but many will

[2] Source: Merrill Lynch (2008) based on Perez, C., 2002, Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages, Edward Elgar, UK.

and these technologies will have the potential to drive an exciting low-carbon future. And the potential for energy efficiency and a low-carbon economy from technologies that we know now is already very strong.

Low-carbon growth, when established, will be more energy-secure, cleaner, quieter, safer and more bio-diverse than high-carbon growth: far more attractive than what has gone before. Indeed, high-carbon growth will kill itself on the very hostile physical environment it will create. It is not a serious medium-term option.

China is very well placed to lead the low-carbon industrial revolution and reap the great benefits it offers beyond the fundamental gains from reducing the risks of climate change. China has already captured a large share of existing global low-carbon energy markets and its share is likely to grow strongly. These world markets will probably be worth many trillions of dollars per annum by the 2020s.[3] And the new industrial revolution will go far beyond low-carbon energy to include agriculture, forestry, buildings and energy efficiency in all its forms. Indeed the energy efficient, low-carbon economy will be everywhere.

Competition for these new global markets will be strong. For example, South Korea is showing leadership with its National Strategy for Green Growth, which includes a target to increase exports of green goods in its major industries from 10% in 2009 to 22% in 2020.[4]

It is a profound and dangerous mistake to ignore these opportunities and to see the transition to low-carbon growth as a burden and a growth-reducing diversion. That mistake arises if you apply the crude growth models from the middle of the last century with their emphasis on fixed technologies, limited substitution possibilities, and simplistic accumulation. Modern growth models are about learning and technical change, and about substituting new inputs; and these models will also have to embrace interactions with the environment in terms of its influence on possibilities for both consumption and production. Delay along the road to transition will lock in high-

[3] Source: Bloomberg, "HSBC Says Low-Carbon Market Will Triple to $2.2 Trillion by 2020", 6 September 2010. See: http://www.bloomberg.com/news/2010-09-06/hsbc-sees-market-for-low-carbon-energy-tripling-to-2-2-trillion-by-2020.html

[4] Source: OECD, 2010, Korea's green growth strategy: Mitigating climate change and developing new growth engines, Economics department working papers, No. 798. See: http://www.oecd.org/officialdocuments/displaydocumentpdf/?cote=eco/wkp(2010)54&doclanguage=en

carbon technologies that will not only take concentration levels of greenhouse gases to still more dangerous levels, but also leave those who hesitate with stranded assets and outmoded technologies. Delay would force stronger and much more disruptive and costly climate action ten years from now.

It is much better to plan in a careful, purposive and measured way, starting now, for the changes in methods of production and consumption that will be inevitable. That is why I was so happy to learn, from a senior figure in the planning process, about the outline of the 12th plan, published in Chinese a few days ago. It does indeed embody a new model of growth, with its emphasis on domestic consumption and on efficiency. Together they will allow reduced saving rates without reducing growth rates. Further, and also of great importance, are the absolute cap on energy and the close attention to policies to reduce emissions. This plan is a landmark for China and for the world.

**Low-carbon growth in cities**

Cities will be at the centre of the low-carbon transition. Cities are home to half the world's population, produce 70% of the world's GDP, and are responsible for 75% of total emissions of greenhouse gases. By 2050, around 75% of the world population will be living in cities. In China alone, given anticipated urbanisation rates, around 10 to 15 million people will move to cities each year over the coming two decades.[5]

Cities are well placed to lead the transition to the low-carbon economy. Major cities are already setting strong targets. Cities can deliver low-carbon programmes at scale, e.g., recycling schemes, generation of energy from waste, broadband networks, plug-in car points, integrated public transport systems, smart buildings, smart grids and congestion pricing. Cities are communities. You cannot recycle and reuse other than in a community. You cannot have combined heat and power other than in a community. Similarly with public transport and many other aspects of energy efficiency and the low-carbon economy.

Ambitious low-carbon projects in cities will set important examples for others to follow, including in China with the 'Sino-Singapore Tianjin Eco-city' (there has been

[5] Source: UN World Urbanization Prospects, 2009 Revision, and C40. See: http://esa.un.org/unpd/wup/index.htm and http://www.c40cities.org/climatechange.jsp

much progress in the Start-up Area with over RMB14 billion in investment to date)[6] and the recently announced 'National Low-Carbon Province and Low-Carbon City Experimental Project' (provinces and cities, including Tianjin, Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang and Baoding, will develop comprehensive low-carbon growth plans and policies and will incorporate these into 'local' 12th five-year plans).[7]

Cities will also have to make major investments to adapt to a climate which is changing as a result of what we have already emitted and we are likely to emit in coming years. Climate impacts include heat stress, water shortages and flooding, but go much further. If the world delays action those investments in adaptation will have to be much larger and major disruption is likely to be unavoidable.

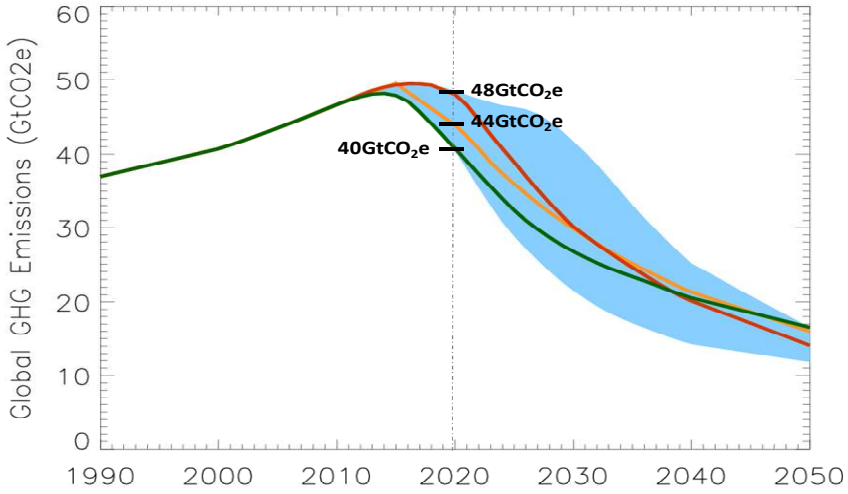
The choices made in cities today on transport, infrastructure, buildings and industry, as they grow rapidly over the coming decades, will determine, via the technology and way of life they lock in, whether humankind can both manage climate change and capture the benefits of low-carbon growth.

**From direction of change to the magnitude of change**

Whilst there are some, albeit limited, options on timing of reductions, global emissions paths that can achieve a 50-50 chance of meeting the 2°C goal would need to peak within 10 years. Figure 2 illustrates global emissions paths consistent with limiting average global temperature increases to no more than 2°C. Starting at the current global level of 47 billion tonnes of $CO_2$e p.a., the most plausible paths pass well below 35 billion tonnes of $CO_2$e in 2030, and well below 20 billion tonnes of $CO_2$e in 2050. These numbers, 35 billion tonnes in 2030 and 20 billion tonnes in 2050, are crucial.[8] If we are serious about a reasonable chance of 2°C they are essentially global constraints. If we break them as a world it will be very difficult to catch up later. We cannot negotiate with the environment and the laws of physics and chemistry.

[6] See: http://www.tianjinecocity.gov.sg/
[7] See: http://english.peopledaily.com.cn/90001/90778/90862/7110049.html
[8] Source: Stern, N., 2009, Deciding our future in Copenhagen: will the world rise to the challenge of climate change? Policy brief, December, Centre for Climate Change Economics and Policy, and Grantham Research Institute on Climate Change and the Environment. See: www2.lse.ac.uk/GranthamInstitute/publications/Policy/docs/PBStern_copenhagen_Dec09.pdf

Figure 2: Paths for global annual emissions that lead to a reasonable chance of a temperature rise of no more than 2°C.[9]




Note: the shaded area represents the range of emissions paths that are consistent with a reasonable chance of the 2ºC goal and the three lines show specific paths within this range.

Given these global constraints, let us examine some basic arithmetic for China. Emissions by China in 2010 are likely to be around 8 to 9 billion tonnes $CO_2e$. If emissions per unit of output were to remain constant between 2010 and 2030, and assuming GDP growth of 7% p.a. (i.e., China's economy doubles each decade), total annual emissions by China would be around 30 to 35 billion tonnes of $CO_2e$ in 2030, exhausting the entire world budget for a 2°C path.

China has indicated in the Copenhagen Accord that it will take voluntary action to decrease carbon dioxide emissions per unit of GDP by 40 to 45% between 2005 and 2020, and to implement this has indicated various targets and policies including for increasing the use of non-fossil fuels and for increasing forest cover. These announced measures together with reasonable growth assumptions, imply total emissions by China in 2020 of around 11.5 billion tonnes of $CO_2e$. A comparable absolute increase between 2020 and 2030 would mean total emissions of 14 to 15 billion tonnes of

[9] Source: Bowen, A. and N. Ranger, 2009, Mitigating Climate Change Through Reductions in Greenhouse Gas Emissions: The Science and Economics of Future Paths for Global Annual Emissions, Policy Brief, December, Centre for Climate Change Economics and Policy, and Grantham Research Institute on Climate Change and the Environment. See: http://www2.lse.ac.uk/GranthamInstitute/publications/Policy/docs/PBMitigatingBowenRangerDec09.pdf

$CO_2e$, nearly half the world's budget for 2030. China's population would likely be around 17-18% of the world total in 2030.

For a 2°C path, the world's average emissions per capita have to be around or below 4 tonnes of $CO_2e$ by 2030 (this is clear from dividing the constraints 'well below 35 billion tonnes' by a likely world population of 8 billion in 2030). Thus China's emissions per capita would likely have to be in 2030 around or below its current level of 6-7 tonnes for the world to have some chance of a 2°C path. That would mean that China would have to return to something like a total of 8-9 billion tonnes of emissions by 2030. In other words, if China is to grow at 7% p.a. for the next two decades and we hope, because China is still a poor country, growth rates will be at least 7%, it would have to cut emissions per unit of output by a factor of 4 over 20 years: if output goes up by a multiple of 4 in two decades and emissions return to their 2010 level in 2030 then emissions per unit of output must be cut by a factor of 4 in that period. This would mean cutting emissions per unit of output by 50% each decade or 29% in each five-year plan.

These calculations are mainly arithmetic starting from where we are and recognising the climate science. They demonstrate what is required for giving the world a reasonable chance of achieving the 2ºC target embodied in the Copenhagen Accord. But they take no account of relative income or wealth, the challenge of poverty reduction, of past history of emissions, or of the questions of whether responsibility for emissions lies with the producer or consumer. All of these are important ethical and political issues. And we must recognise the deep historical injustice in that the rich countries became wealthy with high-carbon growth but the poorest countries will be hit earliest and hardest by climate change. Nevertheless China's size and its growth make it inescapably central to any future efforts to manage climate change.

**Policies for a new low-carbon era**

The basic challenge for policy is how to promote and organise the transition to low-carbon growth. Such a transition, if it is to be made efficiently and creatively, should be fostered by good policy that is both transparent and credible. Policy is vital to correct the profound market failure associated with unpriced greenhouse gases where emitters do not pay for the damage they inflict on others. A price for carbon is

fundamental to correcting this market failure. This price can be explicit via tax or cap-and-trade mechanisms or implicit via regulation. The removal of obstacles to energy efficiency and other innovations through better information and easier availability of products and services, can make a major contribution. Public discussion can help to generate better understanding of the responsibility to save energy and respect the environment. Public investment in infrastructure, including public transport and smart and efficient power grids, can make a vital contribution, not only by lowering costs directly but also by making it easier for others to use or sell clean energy. Financial structures that share risk will also play an important role: government equity participation, loan guarantees, and feed-in tariffs are examples.

China is already demonstrating strong action, not only through its emissions targets, but also by implementing policies on renewables and nuclear energy, through recent 'green' investments in its economic stimulus package, by developing more modern power grids, high-speed rail, hybrid and electric cars, and by afforestation. The planned investment in low-carbon vehicles alone is around US$45 billion over the next five years. The National Development and Reform Commission (NDRC) estimates that 3 million hybrid and 1.5 million electric vehicles will be on the road in China by 2015.[10] In my view China's clear and strong action has been inadequately recognised and understood around the world.

Future action in China could be supported by increasing the taxes on resources such as coal, oil, and gas. There is substantial scope for a greater use of such taxes during the period of the 12th five-year plan. One policy in particular that could provide the right incentives, raise revenue to fund the low-carbon transition, and demonstrate China's commitment, would be to increase the proposed new tax on coal. A 50% coal tax would be approximately equivalent to around $20 per tonne of $CO_2$, the kind of price which should be set world-wide very soon. With consumption of coal in China around 3 billion tonnes p.a., this would raise around RMB1.2 trillion p.a. (around 3% of GDP). Pricing or taxing of other hydrocarbons and the reduction of fossil fuel subsidies can and should also play a role, and should be increased at the same time, again pushing incentives in the right direction and raising substantial revenue for new green, creative and dynamic investments. It is these new investments that will be the

[10] Source: South China Morning Post, "300b yuan earmarked to develop green cars; Clean vehicles priority in Beijing's emissions fight", 13 January 2010. See: http://www.scmp.com/portal/site/SCMP/

routes to competitiveness for the world markets of the future, and thus help China lead the "green race", as well as fundamentally reducing the risks of climate change.

Market-based carbon trading mechanisms can also help China achieve its emission intensity targets efficiently, effectively and equitably. That is why is was so good to learn that in the 12th plan outline it is anticipated that carbon trading will indeed be part of the policy package.

Policies to promote new technologies via support for research, development, demonstration and deployment (RD&D) are also vital. Demonstration and deployment offer substantial benefits to others in terms of learning about what works well or not and thus should be rewarded. Recent research indicates that combining a carbon price with direct support for RD&D is better than any single instrument for bringing forward new technologies.[11] And we must not forget regulation; this can reduce uncertainty, allow for planning on scale and promote rapid action.

Strong policy action in cities will be crucial. The relevant policies have many dimensions and include planning for infrastructure, land use, climate change adaptation, and energy and waste reduction. Cities can lead on RD&D, as they provide knowledge clusters to spur innovation, with high densities of research institutions. Shanghai's plans announced last month to invest strongly in the electric vehicle sector are a striking example of decisive action.[12] Cities can also lead on market-based trading mechanisms. Shanghai, Beijing and Tianjin have established voluntary environmental exchanges. Other cities in the region have established city-wide cap-and-trade schemes (e.g., Tokyo in April 2010), ahead of national actions.[13]

**Conclusion**

China’s commitment to a low-carbon economy has been under-appreciated around the world. The green stimulus of 2008/2009, strong investment in rail transport, regulation of vehicle emissions, rapid growth in production and use of renewables,

[11] For example see: Aghion, P. et al., 2009, No Green Growth Without Innovation, Bruegel Policy Brief, No. 7, November. See: http://www.bruegel.org/nc/publications/show/publication/no-green-growth-without-innovation.html
[12] See: http://www.businessgreen.com/business-green/news/2269233/shanghai-powers-ev-hub-4bn
[13] See: http://www.c40cities.org/bestpractices/buildings/tokyo_emissions.jsp

reforestation, and strong emission intensity targets, are all evidence of this commitment.

Low-carbon growth in China is vital both for China's future and that of the world as a whole. The urgency, the scale of the required changes and the magnitude of the opportunities in the new economy, mean that green policies should be at the heart of the 12th and 13th five-year plans; and we already know that they are central to the 12th plan. Given that total global annual emissions of greenhouse gases must be cut by about 30% in the next 20 years, China's size implies that if the world is to have a reasonable chance of holding global warming to no more than 2°C above pre-industrial levels, then China's total annual emissions should return to no more than current levels of 8 to 9 billion tonnes by 2030. China can build on the advances in energy efficiency achieved through the 11th five-year plan. A 20% reduction in energy per unit of output, as in the 11th plan, together with a 10% reduction in emissions per unit of energy would create a 28% reduction in emissions per unit of output over the next five years, approximately what is necessary to limit warming to no more than 2°C. This would approximately halve emission per unit of output over two five-year plans, if achieved in each plan. This is a stronger level of ambition than currently envisaged but would be necessary to have a reasonable chance of limiting warming to no more than 2°C, given that growth rates of 7 per cent would lead to a doubling of output each decade. Strong policies at both the national and the local level would both raise resources for new investment and give incentives to achieve these targets effectively, efficiently and equitably. Such targets and policy action would not only help to put the world on track to limit warming to no more than 2°C, they would also show the world what is possible and the opportunities that are available. China has recently introduced a tax on natural resources, and plans to apply this to coal: a strong increase in such taxes, together with a cap and trade scheme under discussion, could move incentives powerfully in the right direction. It would be the real growth strategy: high-carbon growth has no future. Low-carbon growth is the model for the 21st century. We cannot afford to continue with the outmoded theory and practice of the 20th century. That is why the 12th five-year plan, quite rightly, embraces this new model.

The argument that low-carbon growth is not simply the only realistic possible future, but also very attractive, must be won, both because it is correct and because the

alternative path is so dangerous. And it must be won across the world. The current position is deeply inequitable: developed countries became rich on high-carbon growth, but poor countries are hit earliest and hardest, and all countries must find a new way.

China's size and growth make it inescapably central to the response. There is no country more important than China in leading the way to a radically different, more dynamic, and much more desirable form of growth. There is no more important power than the power of the example. China and the world as a whole have so much to gain from its leadership.

I am a long-time admirer and friend of China. Let us celebrate what China has achieved and let us look forward to what China and its cities will achieve for a greater harmony between the economy and our planet, along the path outlined in the 12$^{th}$ five-year plan. And finally, let us celebrate the great triumph of the Shanghai Expo, which it was an honour to address.