THE TRANSITION TO A LOW CARBON ECONOMY:

IMPLEMENTATION ISSUES AND CONSTRAINTS

WITHIN CHINA'S CHANGING ECONOMIC STRUCTURE

Report to the Australian Department of Climate Change of the
More Sustainable Energy Use in China: Economic Structure and the Application of New Technologies Project
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Centre for Strategic Economic Studies

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Developed and produced by:

Centre for Strategic Economic Studies

Victoria University

Melbourne, Australia

With assistance from:

Energy Research Institute,

National Development and Reform Commission

Beijing, P.R. China

For further information:

T +613 9919 1329

F +613 9919 1350

alex.english@vu.edu.au

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Acronyms

ADB	Asian Development Bank
BAU	Business as usual
BTU	British thermal unit of energy equal to about 1.06 kilojoules
CAS	Chinese Academy of Sciences
CDM	Clean Development Mechanism
CEACER	China Energy and CO_2 Emissions Report
CEWC	Central Economic Work Conference
CO_2	Carbon dioxide
$CO_{2\text{-}e}$	Carbon dioxide equivalent
CSES	Centre for Strategic Economic Studies
ECS	Energy Conservation Scheduling
EIA	United States Energy Information Administration
ELCE	Enhanced low carbon
ERI	Energy Research Institute
EU	European Union
FYP	Five Year Plan
GDP	Gross Domestic Product
GHG	Greenhouse gases
GW	Gigawatts
IEA	International Energy Agency
kW	Kilowatts
kWh	Kilowatt hours
LCE	Low carbon economy
MW	Megawatts
NBSC	National Bureau of Statistics China
NCGCC	National Coordination Group on Climate Change
NDRC	National Development and Reform Commission
NEA	National Energy Agency
NEC	National Energy Commission
NLGCCS	National Leading Group on Climate Change Strategy
NLGESPR	National Leading Group on Energy Saving and Pollution Reduction
NPC	National People's Congress
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic (solar cells)
RMB	Renminbi or Chinese National Yuan
SGCC	State Grid Corporation of China
SMEs	Small and medium-sized companies
TCE	Tons of coal equivalent
TPY	Tons per year
US	United States
VAT	Value added tax
WRI	World Resources Institute

Introduction

The rapid rise of China's economy on the global stage needs little introduction after 30 years of annual GDP growth averaging nearly 10%. The relatively smooth and stable process of transforming the world's most populous nation from a poor, largely rural and isolated centrally planned economy into a globally-integrated market-orientated manufacturing, industrial and trading global powerhouse is the envy of many nations. While China's pattern of development has transformed society and the economy, there is growing concern that this pattern is unsustainable in terms of environmental and social costs as well as future economic growth. The concerns about the impact of human-induced climate change has focused global attention upon China's development path. A path that has catapulted China into the unenviable position as the world's largest emitter of carbon dioxide, the main greenhouse gas (GHG) (Levine & Aden, 2008).

During the past decade, the pace and pattern of China's economic development has intensified the process of energy and resource intensive, industry-led growth. Energy intensive industry has become one of the key drivers of China's rapid growth during the past decade. Recent data shows that the growth in energy production and use has outpaced many reputable recent predictions (IEA, 2002; World Bank, 2002, 2007; McKinsey, 2007). In recent years, the use of primary energy and the construction of new electricity generation capacity have grown at percentage rates equal to and above that of real GDP. According to Andrews-Speed (2009), the reversal occurred for three reasons: the structural bias towards energy intensive heavy industry; a slowdown in technical innovation; and, a return to coal as the key energy source. Not only have these developments reversed earlier energy efficiency gains from structural adjustments and productivity gains, but they have exacerbated concerns about energy security, resource scarcities and environmental pollution.[1] Moreover, this growth has reinforced an underlying high dependence on black coal as the dominant source of primary energy, with its carbon emissions at two to three times the level of other primary fuels.

China has already taken many initiatives to this end. But the challenge facing China – to reorient a rapidly growing, highly complex and dispersed economy and to achieve rapid adoption of new technologies and clean energy sources – is massive. In recent years, a low carbon economy has been identified as a concept that could act as a vehicle for tackling these challenges. Accordingly, a growing chorus is demanding urgent economic adjustments towards cleaner primary energy forms for both new growth, and indeed to substitute away from the current dependence upon black coal within existing energy applications in the industrial, commercial and retail sectors, and especially in power generation. Retaining the current pattern of economic development based upon coal-powered energy intensive industry-led growth is not a viable option, economically, socially nor environmentally.

The Chinese government recognises both the need for structural adjustment to the economy, as well as weaknesses in state action for rebalancing. For example, in his 2006 Report on the Work of the

[1] Energy security is one of the key drivers of energy efficiency policies due to China's increasing reliance upon imported oil and petroleum products since it became a net oil importer after 1993.

Government to the National People's Congress (NPC), Premier Wen Jiabao reflected on these failings during the 10th Five Year Plan (2001-2005):

> *The main problems were an unbalanced economic structure, weak capacity for independent innovation, slow change in the pattern of economic growth, excessive consumption of energy and resources, worsening environmental pollution, serious unemployment, imbalance between investment and consumption, widening gaps in development between urban and rural areas and between regions, growing disparities between certain income groups, and inadequate development of social programs. We need to work hard to solve all these problems.*

These challenges are common to many countries, but what is unique about China is the scale and complexity of them, given China's rapid growth, extent of international engagement and decentralised development and governance model. In China's unique circumstances, the efforts of the Chinese government to achieve these ends are hindered by so-called implementation gaps, including limited information on how specific policies might best be implemented, on how successful they are likely to be, the level of actual implementation at the local level and on what this means for the choice of preferred policies.

Reflecting the complexity and seriousness of China's economic, environmental and social problems, the Chinese government has introduced a broad range of responses aimed at 'harmonising' development, including adjusting the economic structure away from a heavy reliance on manufacturing exports and investment in industrial capacity as the drivers of economic growth as well as diversifying its energy mix. A key component of the current rebalancing program is the adoption of the low carbon economy concept. This concept aims to decouple the relationship between energy and development. A low carbon economy, it is hoped, offers a new competitive economic advantage for growth whilst tackling the dichotomy between environment and development. In other words, the state is committed to a policy of rapid economic growth but wants to avoid the concomitant environmental impacts, the resource degradation and irreversible climatic change.

There are three key areas of focus for the Chinese government in implementing a low carbon economy. Firstly, the state is attempting to stimulate the adoption of advanced technologies, processes and practices which are both energy efficient and more environmentally benign. Secondly, it aims to shift the pattern of economic activity from energy intensive areas (for example, specific forms of heavy industry) to industry and service sectors that are knowledge intensive and are less reliant on energy and other resource inputs. A third consideration is at a deeper level – the need to shift the development model away from traditional patterns of the developed world. Instead, China is proposing a new path that promotes development whilst lifting the quality of life of its people, without relying upon the unsustainable utilisation of resources.

The sustainable use of energy and energy efficiency in particular are the subject of a considerable amount of recent and ongoing body of work within China and internationally.[2] Achieving improvements

[2] Key Chinese documents on the importance of energy efficiency include CAS (2009), Jiang et al. (2009), CEACER (2009). At the international level, one of the most consistent sponsors of quality research on energy efficiency in

in energy efficiency is a high priority for China given the significant attention the issue has received amongst the leadership of the government. The status of energy efficiency programs have been gradually elevated to key policy priority since they were first identified as a prerequisite of ongoing national development at the commencement of the economic reform agenda in the late 1970s. A great deal of work has been undertaken on the first issue of technical and other characteristics of individual low carbon and energy efficient technologies, most notably in the expansion of nuclear power generation and the renewables sectors of hydro, wind and solar (Wang and Watson, 2009; WRI, 2009). China has also taken a leading role in terms of enacting energy efficient standards for buildings, household appliances and motor vehicles (The Climate Group 2008, 2009). But in any given situation, such as that of contemporary China, there are many obstacles to the increased use of new products and processes that are known to be both technologically and economically superior. These include costs already sunk in existing technologies, uncertainty about the extent of market capture from investing in new technologies, resistance from various economic and social groups, including consumers and vested interests, a desire to protect national or regional interests and firms, inadequate central government authority to impose change, and so on.[3] As a result, the success of the rebalancing efforts to date remains mixed, especially in terms of adjusting the economic structure.

China is currently at an important turning point in rebalancing its pattern of development. The urgency of these issues are paramount given China's ambitions to triple the size of its economy by 2020, accelerate its urbanization process and lift the living standards of its people; all of which will further boost demand for limited energy and resources and double its carbon emissions. This report addresses these issues in five parts. It begins with a discussion of the structural economic characteristics of these issues and analyses their implications for energy use. In the second part, the role of the state as both a driver and obstacle for change is examined including a review of key policy measures. This is followed by an analysis of the implications of China's present and future economic structure on carbon emissions. The report then focuses on possible pathways for rebalancing the economic structure, including the role of a low carbon economy as a catalyst for gradually shifting away from the existing narrow and unsustainable approach to development. The final part reviews the progress to date in rebalancing the economic structure and introduces several issues requiring further work and consideration.

China comes from the Lawrence Berkeley National Laboratories (LBNL), but other important works have been produced by the NRDC & BCG (2009), WRI (2008, 2009), World Bank (2007, 2008, 2009), McKinsey (2008), the Climate Group (2008, 2009) and Chatham House & E3G (2008) amongst others.

[3] These issues are elaborated on in the final report of this project relating to the three case studies of motor vehicles, air conditioners and natural gas.

Changing the Economic Structure

A key focus of this report concerns the extent of structural reforms needed to rebalance China's pattern of development. Much of the current debate around China's economic structure emphasises the nation's 'capital-intensive, industry-led' mode of development and the weak presence of domestic consumption, service industries and social welfare. Vague terms such as 'harmonious society', 'moderately well-off society', 'scientific mode of development', 'ecological society', a 'low carbon and circular economy' and 'new energy revolution' have entered the official discourse to highlight the recognition by the state for a more balanced path of development, including greater social equity and environmental protection (Fewsmith, 2004). Yet despite the new rhetoric, the key ingredients of China's industrial-led development strategy remain in place; namely, the provision of easy access to credit and the underpricing of inputs, particularly resources, capital, land and the environment. Moreover, it is increasingly evident that the impact of the recent global financial crisis and the government's stimulus package are reinvigorating the tried and true mode of economic development: high investment in infrastructure, heavy industry and manufacturing.[4]

The organisation of this section is in three parts. The first part outlines the context of China's pattern of development during the post-Mao period. It follows the initial inertia of the economy to shift away from an established 'hot, wet and heavy' pattern of economic production and growth and the state's adoption of a more aggressive state response for the structural rebalancing of the economy. This is followed by an analysis of the relationship between the structure and intensity of China's energy use with a focus on the role of energy intensity at the sectoral level.

[4] The key priorities of the 2008 stimulus package includes: rural infrastructure, rail transport, affordable housing and the reconstruction of the 2008 earthquake areas.

China's Pattern of Development

During the past two years, China defied a global economic recession, the collapse of its exports and two major natural disasters to achieve rapid economic growth rates.[5] In 2008, the nation's GDP grew by 9.6% to RMB31.405 trillion and then grew by a further 8.7% during 2009 to RMB33.535 trillion (NBSC, 2010). Given China has a population of over 1.3 billion, this equates to a GDP per capita of around RMB25,000 or RMB40,000 on PPP basis (Figure 1).[6] Following the global financial crisis, China is the second largest economy on PPP terms, is the largest trading nation, the second largest manufacturer and the leading engine of the global economy. Significant and unprecedented improvements in living standards have also taken place due to China's rapid economic growth. Today, Chinese cities are bursting with commercial and construction activity; filled with glistening architecturally -designed skyscrapers; and, congested with modern cars shifting its citizens who are adorned in name-brand and luxury clothing and accessories. Beyond the cities half a billion people have been lifted out of poverty since 1981 (World Bank, 2009c). However, China is a nation of contrasts and remains a low to middle income nation due to the disparity in wealth between rich and poor; urban and rural; and, coastal and hinterland (Naughton, 2007). While there is growing wealth and opulence in China, over 300 million continue to live on less than US$1.25 per day.

The development experience of China echoes much of what was experienced elsewhere in East Asia, especially in post-war Japan and then Korea. What the figures don't reveal are the complexities and challenges that China has overcome to achieve such sustained levels of economic development. Moreover, it is clear that many more challenges remain in the coming decades, some old and understood, others new and unknown. Conventional neoclassical economics struggles to provide a useful theoretical framework for explaining China's economic development (Naughton, 1991; Rawski, 1994; Young, 2000; Coase & Wang, 2010). Moreover, many remain cautious about predicting the nation's future trajectory. In contrast, the Chinese government in Beijing remains confident that they will find the best balance in the future pattern of economic development. And yet, many local government officials are deeply tied to the current pattern of development with high levels of investment in energy intensive heavy industry and export-orientated manufacturing. It remains very difficult to persuade these officials that the existing strategy is inherently unsustainable when it has delivered consistently high levels of economic growth. One thing though that is increasingly apparent to many outside local government is that even if China's 'economic structure changes in the future (with less emphasis on resource-intensive manufacturing and exports) the current development trend is not sustainable' (World Bank, 2009c, 8). In order to appreciate this statement, it is necessary to briefly introduce China's pattern of development over the past three decades.

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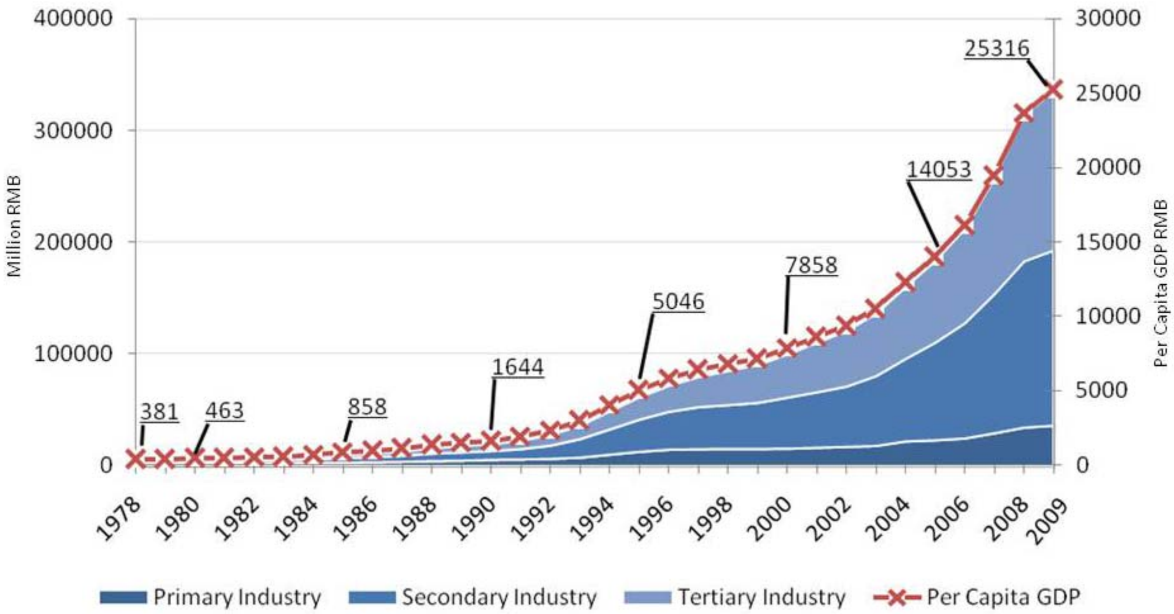
[5] In early 2008, China experienced severe winter storms in southern China. These storms crippled the nation's transport system resulting in serious logistic delays and exacted a heavy economic toll. Just three months later, a massive earthquake struck the central province of Sichuan killing up to 80,000 people, resulting in major social and economic disruption. Then in September 2009, the world experienced what is now referred to as the global financial crisis. This economic slowdown dragged nearly all developed economies into recession and dramatically reduced demand for China's exports.

[6] The Chinese Yuan (RMB), otherwise known as renminbi (RMB), is mostly used in this report with an exchange rate of: RMB1 = US$0.146 or US$1 = RMB6.829

At the beginning of China's economic reforms in the late 1970's, Deng Xiaoping called for the creation of a *xiao kang shehui* (小康社会) or well-off society by 2000 with a doubling of GDP per capita to US$800. The resulting reforms resulted in an incredible transformation of the economy so that nominal GDP per capita expanded 330% between 1978 and 1990 from (see Figure 1). It would be inaccurate to describe China's post-1979 period of economic reform as a head long rush into a capitalist market economy. Instead, pragmatism and gradual adjustment have marked the process of market-orientated reforms and opening up to the global economy. Deng's dictum of *crossing the river by feeling the stones* (过河摸石) reflects the important role of experimentation in loosening market and social controls whilst constantly assessing the political and economic impact at each stage. The state remains acutely aware of the impact of the reform process on historical traditions, including the natural and human resource base, formal and informal economic, social and institutional structures and the attendant risks of policy mistakes.

China's economic growth has been driven by a series of gradual reforms commencing with agriculture and the service sector followed by the more recent rapid expansion in industry and manufacturing. During the 1980s, the growth rate of value added in both agriculture and services more than doubled relative to the 1970s, to 6.2% and 12.3% respectively, while there was little increase in the growth rate in industry (see Figure 1). The services share of GDP rose more than eight percentage points between 1980 and 1990, and over this time the primary and tertiary sectors contributed 62% of total growth. As a result, Deng's target was realised almost a decade earlier than expected.

Figure 1: Gross Domestic Product (GDP) by Sector and Per Capita, Current Prices



Source: NBSC 2009, 2010

These dynamics changed substantially during the 1990s, as the expansion of industrial activity, linked into global markets and driven in significant part by foreign investment and a more competitive currency, became the main source of growth. Between 1990 and 1997 real industrial GDP grew by 15.7% per annum, while growth in both the agricultural and services sectors slowed. As a result, the industrial share of GDP rose sharply from 37.0% to 48.9% between 1990 and 1997, and secondary industry contributed to 60% of the growth of real GDP during this period. While the first two decades of economic reforms reduced the number of people living on less than $1 a day from 650 million to 200 million, the pattern of development was regarded as at "a low level", "not all-inclusive" and "very uneven" (Jiang Zemin, 2002). Therefore, the "main task of economic construction" remained the building of a *xiao kang* society based upon the tripling of GDP, increasing the rate of urbanisation above 50% and reducing the ratio of rural employment from 50% to 30% between 2000 and 2020.

Following the economic slowdown brought about by the East Asian crisis (1997-98), the real value added of the Chinese industrial sector doubled between 2001 and 2007.[7] This lifted China's output of industrial products to levels constituting a major proportion of total world output. As shown in Figure 1, GDP growth accelerated between 2004 and 2007 when it reached 13%. This expansion was largely fuelled by industry; making up nearly 60% of GDP growth compared with around 32% for services and agriculture less than 10%.[8] In 2008, China's merchandise exports were worth almost RMB10 trillion, five and a half times their 2001 level of RMB1.8 trillion. There is thus much reality to the current cliché of China becoming the 'factory of the world'.

The combination of burgeoning exports and high levels of fixed asset investment are undoubtedly closely related. Creating the capacity for such a high level of exports required heavy investment in fixed assets, not only within firms but also in a wide range of economic and social infrastructure, ranging from power stations, ports and railways to housing and urban facilities. Revenues being received by various parties, both firms and government agencies, from the export boom would also assist with the financing of that infrastructure. Thus the third feature of this period – a further rise in the role of the industrial sector in driving China's growth – is perhaps an inevitable result of these two trends. As a result, the share of secondary industry in GDP rose from 46% in 2001 to 48.6% in 2008, with virtually all the relative decline in the primary sector being taken up by industry.

The export of manufactured goods has played a central role in China's rapid economic growth during the past thirty years. While manufacturing contributes 40% to China's economy, exports make up 34% of GDP and experienced very strong growth between 2001 and 2008. In 2007, exports grew by 26% and then by a further 21% in 2008. Despite attempts to rebalance growth away from the industrial and towards the service sectors, industry continues to outpace services and investment outpaces consumption. Although in a slight shift in the balance of growth between the service and industry sectors, 2008 resulted in the first time since 2003 that the added value of the service industry exceeded

[7] Ironically, many of the current imbalances resulted from the government's economic stimulus program following the East Asian Crisis, which led to a massive surge in heavy manufacturing investment (much of it capital, energy and pollution intensive) to retain the pace of economic growth.

[8] China's own statistics are slightly different. See for example, the Statistical Communiqué of the PRC on the 2008 National Economic and Social Development (27 February 2009).

the growth rate of the secondary industry.[9] The share of the service sector in GDP was 41.8% in 2008, compared to an average of 70% in high income nations and 54% in middle income nations. China's pattern of economic growth is therefore described as capital intensive and industry-led, which has contributed to 60% of GDP growth during the past decade.

Given the scarcity of disaggregated data on Chinese industrial production in real terms, some illustration of that growth is provided in Figure 2 in terms of selected items in physical units. Each of the items shown in the table has grown very rapidly between 1990 and 2008.

Figure 2: Production of Major Industrial Products, 1990-2008

	Air conditioners (m units)	Household refrigerators (m units)	Colour TV sets (m units)	Crude steel (m tons)	Cement (100m tons)	Motor vehicles (m units)	Micro-computers (m units)
1990	0.2	4.6	10.3	66.4	2.1	0.5	0.1
1995	6.8	9.2	20.6	95.4	4.8	1.5	0.8
2000	18.3	12.8	39.4	128.5	6	2.1	6.7
2001	23.3	13.5	40.9	151.6	6.6	2.3	8.8
2002	31.4	16	51.6	182.4	7.3	3.3	14.6
2003	48.2	22.4	65.4	222.3	8.6	4.4	32.2
2004	66.5	30.3	73.3	272.8	9.7	5.1	59.7
2005	67.7	29.7	82.8	352.4	10.6	5.7	80.8
2006	68.5	35.3	83.8	419.1	12.4	7.3	93.4
2007	80.1	44	84.8	489.9	13.6	8.9	120.7
2008	82.3	47.6	90.3	500.9	14.0	9.3	136.7
2009	84.2	59.3	104.5	568	16.4	13.4	185.2
Estimated share of total world production, 2009 (%)							
	80	na	na	45	52	13	na

Source: NBSC, 2009 and author estimates

In 2009, China accounted for around 45% of global crude steel production due to a dramatic ramping up of capacity and production between 2001 and 2008 when it grew 300%. Production of non-ferrous metals, particularly aluminium, is also expanding sharply. Cement production, for which China accounts for over half of world output, continues to grow strongly, to meet the demands of the construction boom. Motor vehicle production is also increasing rapidly from a strong base, with China now the world's largest vehicle manufacturer and market with domestic sales exceeding 13.6 million units in 2009; a rise of 46% on 2008 figures. The automotive sector is likely to be an important next stage of China's export expansion, with exports of automobiles and automobile components expected to increase from US$ 10.9 billion in 2005 to US$70 billion by 2010.[10]

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[9] See the State Council document 'The Opinions on Implementing the Policies and Measures for Accelerating the Development of the Service Industry' for further details of the government's policies to strengthen the service industry.

[10] Xinhua Online, 19 September 2006.

China’s entry into the World Trade Organisation (WTO) and a strong global economy has produced, since 2001, a striking new stage in China’s development.[11] Prior to China’s entry to the WTO, China shared the impetus for global growth with Europe and North America of around 17.6%, 19% and 24%. However, since then, China’s proportion of global growth has almost doubled. China’s entry into the WTO not only gave China increased access to global markets, but also stimulated further interest on the part of multinational companies in basing production for world markets within China, and led to a further increase in foreign direct investment. Much of these exports still seem to involve relatively low value added production or assembly operations, although the government is seeking to increase the value added level through the increased application of science and technology.

Since 2001, the economy has been driven by very rapid growth in exports and in fixed asset investment, which are reflected in the growth in industrial output. The combination of the three measures – exports as a share of GDP, the ratio of fixed asset investment to household consumption spending and the secondary industry share of GDP – are at historically high levels, and are likely to increase further in the immediate future . A Caixin report (Wang Jing, 2010) referred to National Development and Reform Commission (NDRC) figures for fixed-asset investment during 2009 of over 344,000 new projects worth RMB15.2 trillion, representing a 67% increase on 2008 figures. The report added that “461,000 existing projects with planned investment of RMB42 trillion were continued last year, a 32% increase over ongoing projects in 2008”.

Analysis of the explanations for this rapid growth in investing in infrastructure and heavy industry point to structural economic factors as the key to understanding this issue (Naughton, 2007; Kujis, 2009; Prasad 2009). Imbalances in the economy were created due to several interconnected reasons, including:

- government focus on industrial production to drive growth;
- depressed household incomes;
- high private funding of health, education and social security expenditure;
- low levels of domestic consumption;
- low resource (water and land) and energy pricing;
- perverse incentives for investing in capacity;
- low interest rates which discourage household savings and encourage corporate industrial investment; and
- weak enforcement of environmental standards.

The growth in investment, and heavy industry in particular, has not only played a key role in boosting GDP, it has also resulted in many of the imbalances in the economy with regards to natural resource use, energy consumption and environmental degradation. In 2009, the share of heavy industry in the gross value of industrial output exceeded 70%, which according to Feng Fei of the Research Department of Industrial Economy in the State Councils’ DRC’s, it is the highest since 1959 (Li Jing, 2010).

[11] China has gained considerably from its entry into the WTO because protection in the advanced economies of manufacturing (other than textiles) has almost ceased. This has permitted a surge in the high-technology exports that have had the most widespread benefits to the Chinese economy.

The current economic crisis has occurred at the same time as the Chinese government is attempting to correct this imbalance in economic development. At this stage it is increasingly obvious that the crisis will curtail any of the earlier rebalancing of the economy rather than act as a stimulus towards a sustainable path of development.[12] According to the 11th Five Year Plan (FYP), China aims to increase the share of the service sector in GDP to 43.3%. However, it seems unlikely that the target will be met following the global economic downturn. Instead, between 2006 and 2008, industry growth continued to outpace services. Within the industrial sector, energy-intensive heavy and chemical industries (notably steel, petroleum and aluminium) have further expanded, despite some slowing in late 2008 due to the collapse of global markets. For instance, investment during the first ten months of 2009 in the cement, flat glass and steel industries grew by 64%, 35.3% and 3.8% respectively (Huang, 2010). Recent data suggest that strong growth in China during 2009 defied the global economic slowdown[13] and sharp drop in exports. Instead, growth is estimated to be around 8.7% on the back of high levels of investment in fixed assets, rising levels of domestic consumption and increasing industrial production. In 2010, economic growth may exceed 10% with the growth in investment at the provincial level varying from 10% to 30% (Wang Jing, 2010). Therefore, in terms of China's economy and society and the global climate, adjusting the pattern of development as well as adopting a more sustainable use of energy and limiting the environmental costs that it imposes is of the highest importance.

There is clearly a long road between the government's intention to move to a more sustainable growth path and the reality of overcoming the economic and industrial inertia. Limited capacity to alter the drivers of energy use further constrains the pace of change. Nevertheless, the economic and social pressures for more sustainable energy use and for an improved environment remain central realities in contemporary China. As growth in the world economy slowly recovers, and China's current economic strategy and competitiveness foster further increases in China's share of world markets, export-led, energy-intensive growth is likely to continue at a high level in China for some time to come.

Energy Use

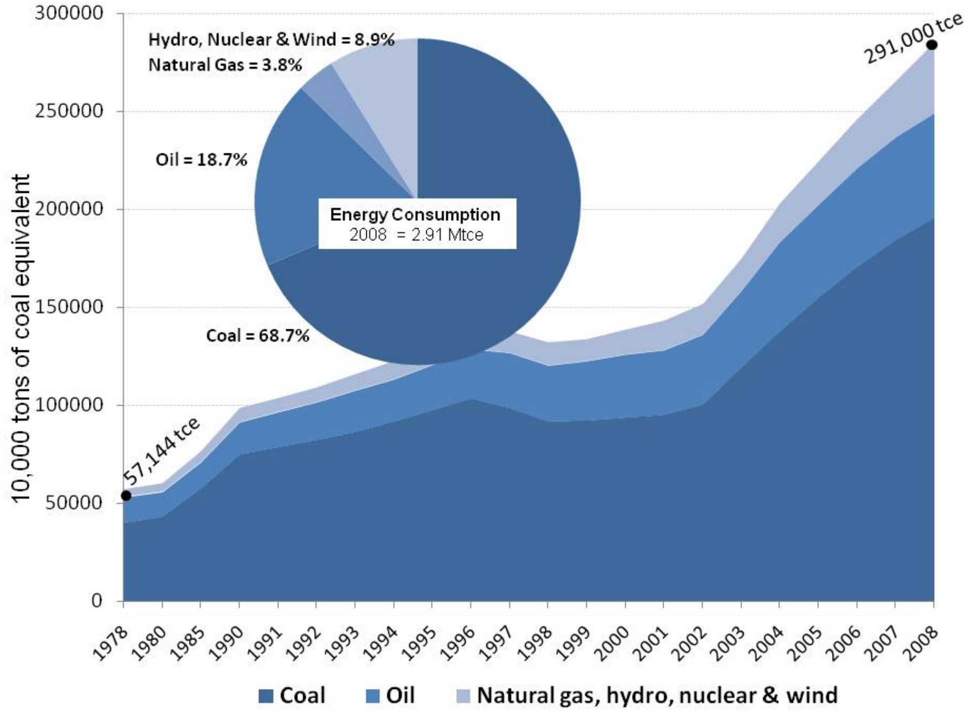
China is in the midst of a period of rapid industrialisation. As mentioned, its development path follows a similar pattern to its neighbours, Japan, Korea and Taiwan. China has learnt from the experience of its neighbours where rapid industrial growth is not mutually exclusive of energy efficiency gains through reductions in resource use and energy intensity. What is unique, however, is the scope and size of its growth as well as the implications of this development for energy use, natural resources and the environment at both the domestic and global level.

[12] The stimulus funding was also aimed at boosting rural living standards and was aimed at complementing existing social welfare programs in the 11th FYP, including RMB70 billion in 2009 for medical reforms and rural subsidies on top of RMB102.8 billion in allocations in 2008. Rural and urban relief programs have also increased RMB3 billion in 2007 to RMB9 billion in 2009 and RMB15 billion to RMB26.6 billion respectively (Naughton, 2009a).

[13] In early 2009, the World Bank, IMF and OECD continued to revise down their estimates of global development, including reducing the rate of China's economic growth in 2009 to around 6.5%. However, these institutions reminded us that global shrinkage would be worse without the modest growth of China. By mid-2009, these same institutions were upgrading global and China growth forecast largely on the basis of sustained economic activity in China following the massive state stimulus package.

The size and speed of China's growth necessitates enormous energy demands, currently second only to the United States. Figure 3 shows how China's energy mix has changed very little between 1978 and 2008. What has changed, however, is the demand for energy and its relationship to economic growth. Between 1978 and 2000, China's economy grew at an annual average rate of almost 10%, whilst annual energy demand grew at 4%. After 2000, economic growth accelerated slightly, yet the growth in energy surged on the back of an intensification of industrial production. Between 1978 and 1991, energy consumption doubled, requiring 14 years. It then doubled again in just seven years between 2001 and 2008. The outcome was that domestic energy supply struggled to keep up with demand causing black outs and brown outs. As a result, investment in new energy capacity and infrastructure accelerated in China as did the demand for energy imports.

Figure 3: China's Annual Energy Consumption Mix, 1978-2008

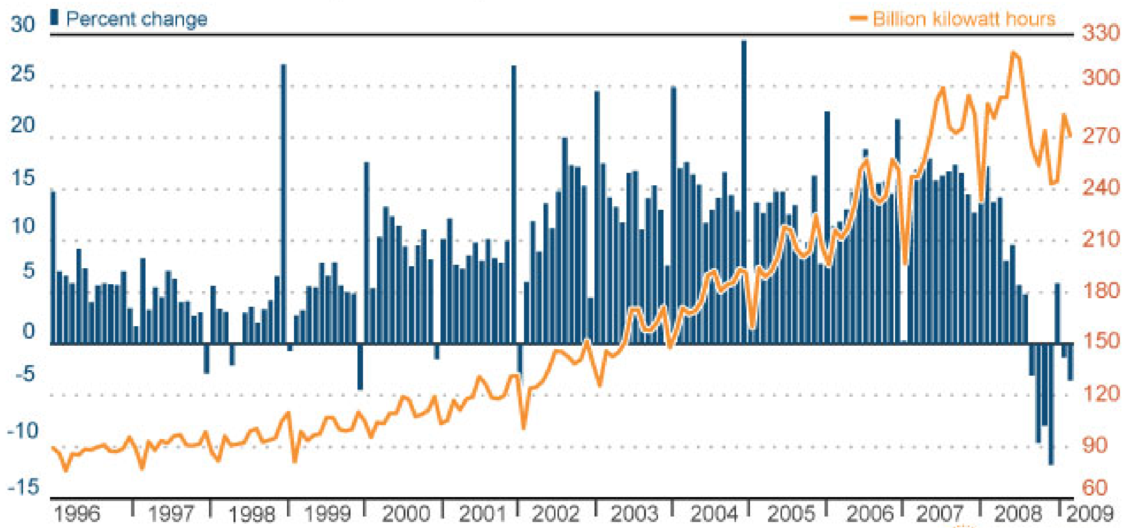


Source: NBSC, 2008

China's heavy dependence upon coal carries significant implications for these growing energy levels. Coal is the key resource in China's energy and power sectors with domestic coal production estimated to reach 3.3 billion tons in 2010. Coals share of primary energy consumption is 69% and in the power generation mix around 80% (Figure 3). Coal's dominant hold on energy supply remains consistent throughout the past thirty years. Oil also maintains a steady grip at around 20% of energy demand with hydro (6%), gas (4%) and nuclear (1%) also contributing. China's total energy consumption in 2008 was estimated at 2.91 billion tons of coal equivalent (tce) with per capita energy consumption being 2.2 tce, representing a 4.2% increase over 2007. China's energy consumption rose to 3 billion tce in 2009 with traditional fossil fuels providing over 90% of the energy. Coal remained steady at around 70% of the energy mix with renewables contributing 8.3%.[14]

Figure 4 highlights the steady growth in China's power generation between 2000 and 2006 when it more than doubled from 100 billion kWh to nearly 240 BkWh with electricity demand growing by around 14% annually. The noticeable decline in power generation growth in late 2007 occurred when the central government started to tighten fiscal and monetary policy in an attempt to slow down the over-heating economy. Figure 4 clearly shows the success of this policy.[15] However, power generation was immediately impacted by the sudden arrival of the global financial crisis which shifted generation into a short decline, followed by a period of stagnation.

Figure 4: China's Power Generation, 1996-2009



Source: National Bureau of Statistics cited in Reuters, 2009

One important aspect of recent developments, relevant both to energy use and to the demand for resources, is the increasing shift to heavy industry in China's industrial production. The strong growth of secondary industry is a key factor for the rebound in the energy to production relationship after 2002 when this sector experienced rapid growth. For example, the overall ratio of gross industrial output almost doubled between 2003 and 2008 from 90% to 160% of GDP. Most of this increase occurred with the tripling of heavy industrial production, notable in the resource and energy intensive sectors of steel, metals, petroleum chemicals, paper and glass production (Figure 13).

The industrial sector currently consumes almost 70% of total primary energy in China with the manufacturing sector alone consuming two-thirds of total energy. It is estimated that China's energy consumption for coal-burning power generation, steel and cement production is still 22%, 20% and 45%

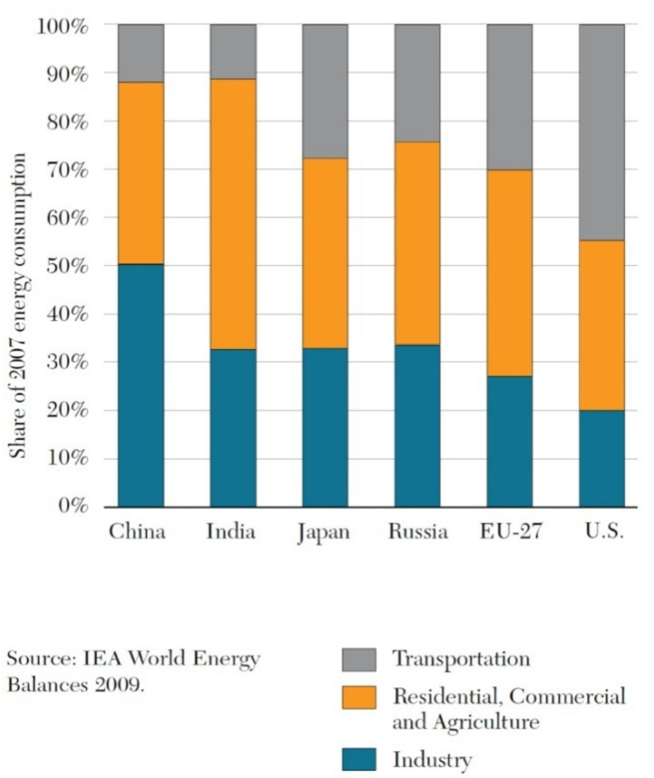
[14] Reuters UK (2009) China renewable energy use 8.3 pct of total in 2009 –official, 20 January 2010 online: http://uk.reuters.com/article/idUKTOE60J03Y20100120

[15] The annual sudden dips in consumption reflect the closure of most industry during the lunar new year festival.

higher respectively than those of advanced levels in developed countries.[16] These high levels of energy consumption also indicate, however, that structural changes and improvement of energy efficiency in energy intensive industries have great potential to contribute to energy conservation.

The strong bias towards industry in China's energy mix is most evident when compared against the international experience. In Figure 5, industry in China consumes more energy than any other country and even twice as much as the United States. Moreover, China's industrial plants remain more energy intensive per ton of output than those within the OECD by an average of 20-40% (Seligsohn et al., 2009). Industry has therefore been the main focus of the government's energy efficiency drive due to the significant benefits that can be achieved.

Figure 5: Energy Consumption by Sector



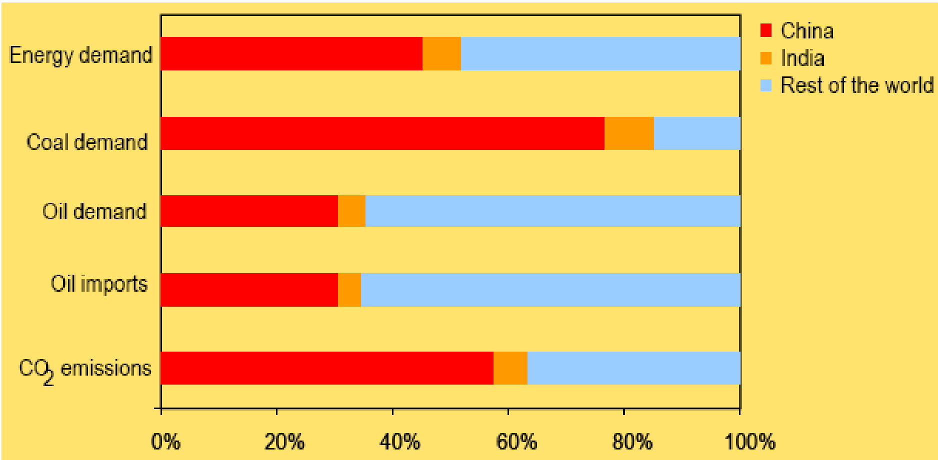
Source: Seligsohn et al., 2009

In 2000, China's primary energy demand accounted for around 10% of global demand, most of which was provided by domestic energy supplies. In the past decade, China's share has expanded to over 16% of global energy demand (IEA, 2009a, 76). A growing portion of this is being sourced from overseas, as evidenced by the booming resource economies of the world. China is relying upon imports for an increasing proportion of its supplies of the oil, gas, coal and uranium it consumes. This trend is apparent

[16] According to Jiang Bing et al. (2010), the energy intensity of China's coal-fired power generation, steel, cement, oil processing and ethylene production are respectively 18%, 17%, 20%, 43% and 57% higher than the world average based upon figures from the National Energy Administration of China (NEAC).

when China's increasing share of key energy resources is examined. Figure 6 shows that in the period 2000-2006, China's energy demand made up nearly half of global energy growth and China's demand for coal contributed to nearly 80% of global growth in this core energy commodity. Then in 2008, China contributed to 74% of net global energy consumption growth and about 85% of the growth in coal usage. There was little change in 2008 in terms of economic structural drivers with the primary, secondary and tertiary industries accounting for 11.3%, 48.6% and 40.1% of GDP respectively. However, in the first 11 months of 2009, heavy industry grew by 22.2% compared to light industry's 12.6%.

Figure 6: China's Increasing Global Share of the Growth in Key Energy Related Indicators, 2000-2006



Source: IEA, 2007

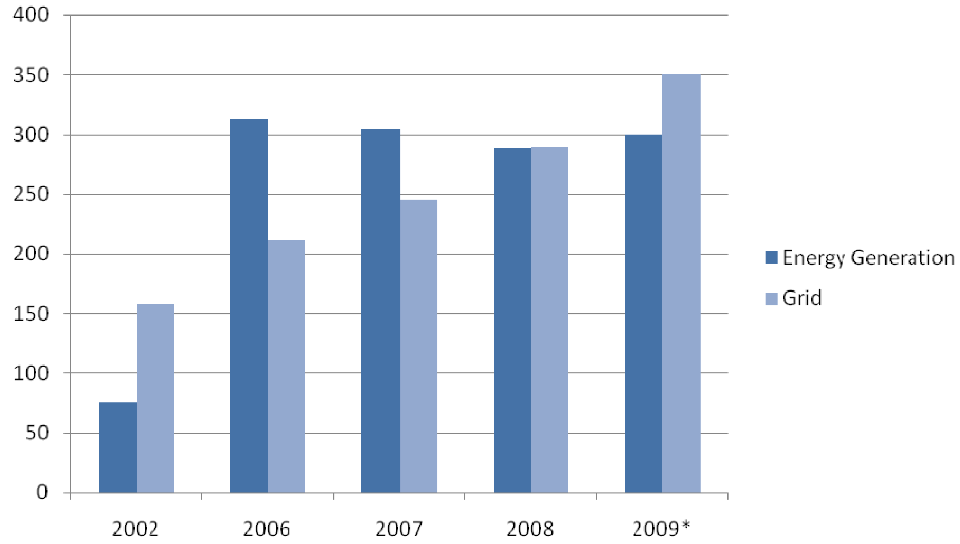
This explosive growth in energy use caught policymakers, energy analysts and energy providers in China unaware. As a result, power shortages emerged between 2001 and 2005 followed by a massive expansion in energy production capability (Figure 8). In response to the energy shortages, China's most-developed coastal regions strengthened policies towards developing their own energy security solutions, instead of relying upon coal from the interior and northern provinces. In the face of rapidly growing demand for power, the wealthier provincial and municipal governments along the industrialized coast are opting to invest in diverse energy supplies, such as nuclear, gas and hydro.

The electricity supply shortage also gave rise to locally-initiated solutions outside the reach of the regulatory framework. For instance, it is estimated that about 10% of China's total electric power consumption is supplied by the so-called 'within-the-fence' diesel generators, the installation of which is said to have been generally tolerated, and in some cases actively supported, by local officials. Environmental regulation of these diesel generators has lagged behind that of central station power plants. As a result, China has now become the world's largest market for industrial diesel generators, and the country's consumption of diesel fuel, much of it produced from imported crude, has climbed substantially.

Meeting the rapidly growing energy demands of the nation remains a serious challenge for the government. In the four years between 2005 and 2008, China increased its electricity generation capacity by 350 GW (see Figure 8) to reach a total capacity of 800 GW.

In order to meet the growing demands on China's energy sector since 2002, the state increased investment in both the supply and distribution network (see Figure 7), including allocating RMB650 billion in the 2009 stimulus package for new generation and upgrading the grid and distribution systems (Fu Jing, 2009).

Figure 7: Investment in China's Power Generation and Grid, billion RMB



Note: * 2009 figure is an estimate.
Source: Shanghai Daily, 2009

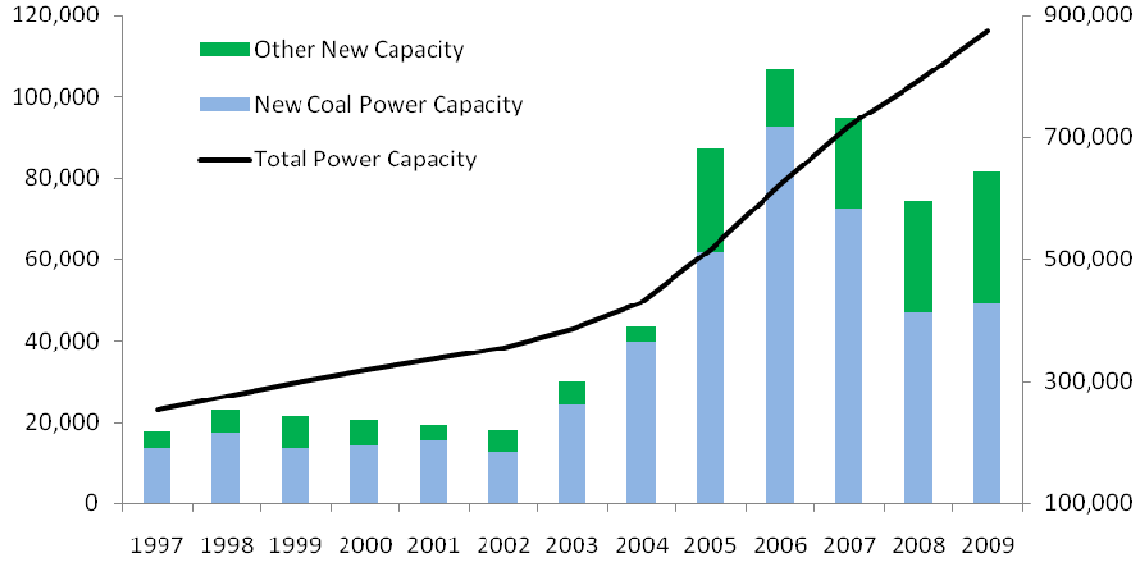
A key component of the spending is the construction of ultra high voltage lines from the east to the west and the north to the south of the country as well as making moves towards developing a smart grid to support the rapid expansion of renewables, which are predominantly located in the north and west of the country.[17] China's existing grid experiences similar problems to other large land masses with weaknesses in the transmission system resulting from large surpluses in some regions and shortages in others. Much of this resulted from a lack of investment in grid and distribution infrastructure prior to 2003 (see Figure 7). Figure 8 illustrates the relatively stable levels of new energy generation capacity up until 2002. However, there has been a spike in investment in new power generation following the growth in heavy industry and resultant power shortages, black-outs and brown-outs in southern China. While the vast majority of the new capacity is supercritical and ultra-supercritical coal thermal power plants, there is strong growth in non-coal power generation, such as hydro, wind and nuclear power plants, since 2005.

As China's coal is mainly located inland, far from the major energy consuming regions along the coast, the government is implementing a clean-coal-based development strategy which favours the development of energy infrastructure with large-scale and technologically-advanced power plants

[17] There have been some recent concerns with progress on the first ultra-high voltage (UHV) AC system between Shanxi and Hubei, which continued to underperform against expectations and remained at an early stage of development (Yu Dawei, 2010).

located in the coal-rich areas of the north and the west, and linked to the coastal regions via long-distance power-grid.

Figure 8: Total Capacity and the Annual Increase in Power Generation Capacity, 1997-2008, MW



Source: CEIC data, 2010

Of the 217 GW of new coal-fired capacity under construction globally in 2008, China contributed around 112 GW or more than half. Most of these new plants are utilising supercritical technology and it is likely that ultra-supercritical technology will play a critical role in the coming decade. As a result of these developments, China's fleet of coal power generators are reportedly more efficient than those found in the United States (The Climate Group, 2009). While the efficiency of China's energy generation is improving, growth in demand continues especially from the expansion of the industrial sector. In order to understand the implications of this expansion for energy use, it is necessary to examine the energy intensity of the economy as a whole as well as adopt a sectoral analysis.

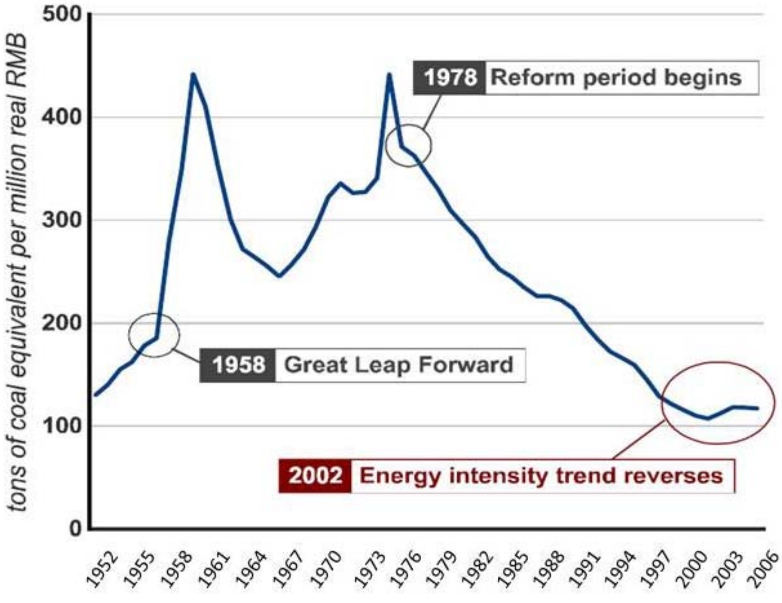
Energy Intensity

Energy intensity is a common measure of the relationship between energy use and the economy. It measures how much energy is required to produce a unit of national revenue. For example, in 2003, China's energy use per dollar of PPP-adjusted GDP was 0.23 kg of standard coal equivalent (sce) or about the same as the United States, Indonesia, South Korea and Malaysia. In contrast, Japan and the European Union used about half the amount of energy or 0.15 kg.

Prior to the 1978 economic reforms, the Chinese economy was both highly energy intensive and highly inefficient in its use of energy. Since the commencement of the 1978 economic reforms, China has achieved consistently improved energy efficiency and energy intensity figures (see Figure 9). A combination of productivity gains through the application of new technology and innovation, government policy measures aimed at achieving energy efficiency and structural economic change led to a sustained reduction of energy intensity during the 1980s and 1990s. As a result, energy use rose more slowly than GDP for the first fifteen years of the reform period, implying a fall in the energy intensity of GDP (Figure 9). China's experience remains generally positive especially when compared to the industrialisation process in Japan and Korea. Energy intensity in Japan between 1960 and 1974 increased 23%, and in Korea it increased 45% between 1971 and 1997.

Interpretation of trends became more complex in the second half of the 1990s, as the official Chinese energy data became unrealistic (Sinton & Fridley, 2003). Between 1996 and 2001 real Chinese GDP was reported to have increased by 46%, but total energy consumption was reported to be 3% lower in 2001 than in 1996, implying a negative value for energy elasticity. By the late 1990s, China's energy intensity was less than a third of 1980 levels. However, since China's entry to the WTO in 2001, the nation's energy intensity has deteriorated (Figures 9). Since 2001, China's energy intensity has increased due to strong investment in industrial production, notably manufacturing and heavy industry particularly of energy-intensive products, such as steel, aluminium and cement. To complicate matters, the post-2001 turnaround in China's declining energy intensity occurred at the same time as the nation experienced a burst of rapid economic growth; the earlier surplus in energy capacity was eroded; and, the energy demand outstripped supply. Additional factors, such as an increasing reliance upon energy imports and bottlenecks in the domestic distribution of energy and fuel supplies exacerbated the serious energy and resource shortages. In response, the government intensified its energy efficiency efforts so that energy and energy efficiency became core government considerations. This section explores some of the reasons for this shift in the relationship between energy and development.

Figure 9: Energy Intensity of the Chinese Economy, 1952-2006

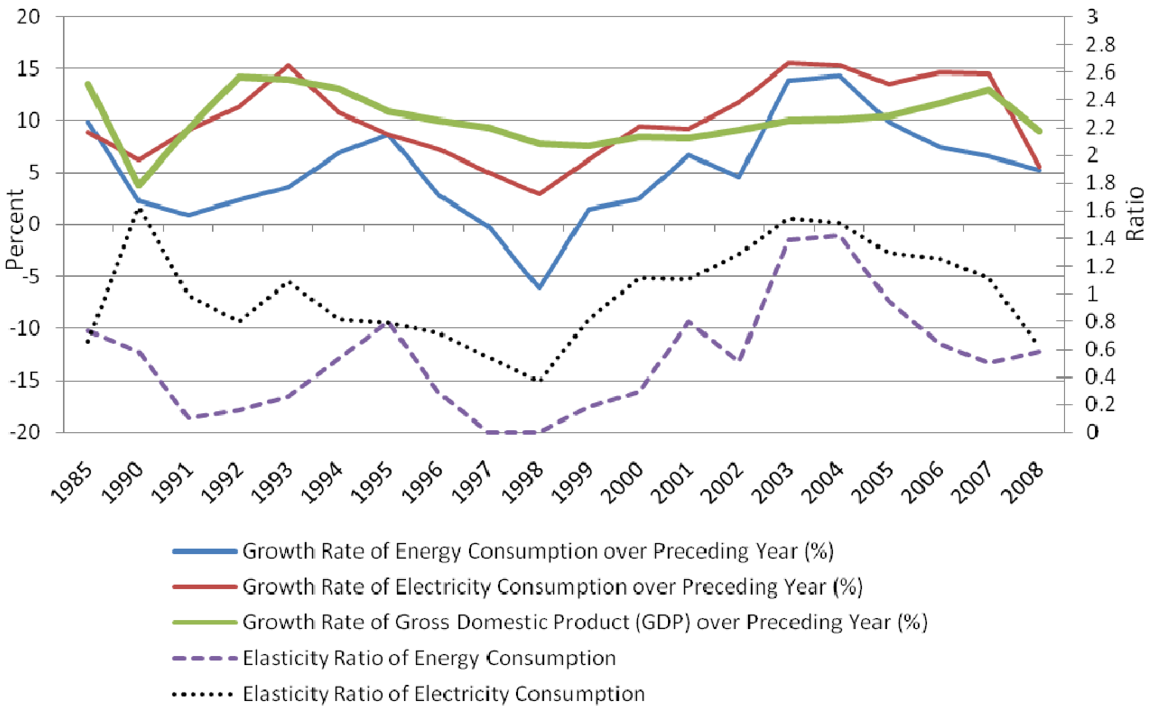


Source: Rosen & Houser, 2007, 6

A key issue in developing projections of energy use is the value for different countries of the energy elasticity of GDP. Energy elasticity is a term that is used in relation to the energy intensity of GDP and reflects the percentage change in energy consumption relative to a 1% shift in GDP. Typically, the elasticity of total primary energy use with respect to GDP is equal to or greater than one during the industrialisation phase of development. However, once a nation achieves higher living standards this elasticity reduces significantly below one, and indeed less than 0.5. The value of the elasticity parameter of energy is a more critical measure, especially when making comparisons between nations. For example, the energy elasticity of GDP for developing countries as a whole was 1.04 over 1971-2002. If China is removed from these figures, the elasticity for all other developing countries over this period was 1.34 compared to 0.57 for China (IEA, 2009d).

Figure 10 shows that prior to 2001, China's energy elasticity was well below one. However, between 2001 and 2005, energy use grew by 11.6%; implying an elasticity of 1.2 over this period.

Figure 10: Elasticity Ratio of Energy Production, 1985-2008



Source: NBSC, 2009

The rise in energy intensity (Figure 9) and energy elasticity (Figure 10) occurred because not only did the economy grow much quicker than anticipated, but this growth was fuelled by a rapid expansion of heavy industry, particularly of energy-intensive products, such as steel, aluminium and cement. Rosen & Houser (2007) explain that the energy demand elasticity grew from under 0.5 between 1978 and 2000 to 1.5 between 2001 and 2006. As a result, energy consumption increased four times faster than originally estimated.[18]

China officially claims that its energy elasticity of consumption was 0.62 in 2008 and -0.24 in 2009 and its energy intensity declined -1.51% in 2008 to 1.13. In fact, China reached a peak energy elasticity figure of

[18] Predictions at this time by the US Energy Information Administration (EIA, 2005) estimated China's energy elasticity at around 1.5. In other words, with GDP growth of 10%, energy demand grew by 15% (see Figure 9).

1.55 in 2003. Initial official estimates suggested energy intensity declined 5.2% year-on-year in 2008, a larger decline than the 3.66% recorded in 2007.[19] This would have resulted in a cumulative improvement from 2006-2008 of nearly 11%. It was then reported that in the first half of 2009, the energy required to produce a unit of GDP dropped a further 3.35% year-on-year reaching an accumulated total of 13.43%. According to the NDRC, the energy intensity of power generation was down 9.51%, oil and petrochemicals were down 8.21%, the coking coal industry declined 3.8%, non-ferrous metals declined 19.59% and steel improved 8.43%.[20] As a result, Premier Wen Jiabao announced in March 2010 that China had reduced its energy intensity by 14.38% (China Daily, 2010).

CSES analysis is at odds with this latest statement and has found that energy efficiency measures have achieved less than half the targeted figure due to the rapid growth of the economy and the ongoing resilience of energy-intensive industrial expansion.

Figure 11 below provides an interpretation trend in real GDP and energy consumption between 2005 and 2010. This covers the period of the 11th Five Year Plan and is based upon the latest data provided by the National Bureau of Statistics and in part as provided on CEIC. The real growth rates for GDP are converted into levels using 2005 as a base. The table implies that over the first four years the reduction in energy intensity has been 7.7%, and that a reduction of about 10% is likely for the full 2005-2010 period. This conclusion is not consistent with other readings of this matter. Nor is it in line with the government's announcements on meeting the 20% reduction in energy intensity by 2010.

Figure 11: Real GDP Growth, Energy Use and Energy Intensity, China 2005-10

	Real GDP (2005 values)	Energy consumption (MT SCE)	Energy intensity Level	Energy intensity 2005=100	GDP Growth (% pa)	Energy Growth (% pa)
2005	18322	2247	12.3	100		
2006	20455	2463	12.0	98.2	11.6	9.6
2007	23122	2656	11.5	93.7	13.0	7.8
2008	25192	2910	11.6	94.2	9.0	9.6
2009	27388	3100	11.3	92.3	8.7	6.3
2010	30400	3364	11.1	90.2	*11.0*[1]	*8.5*[1]

[1]Assumptions for 2010
Source: NBSC, 2010; CEIC, 2010.

There are five areas of doubt about this conclusion:

Firstly, the GDP figures used reflect the increased levels of GDP, and the implied higher growth rates, arising out of the Second Economic Census, released on 25 December 2009, but only for 2008 and 2009. The basis for the GDP figures in Figure 11 is the latest published annual growth rates, for each of the four years. When the revised figures back to 2005 are available, the growth rates for 2005-08 may also

[19] Xinhua report this figure in February 2009 followed by a March report of a higher updated figure of a 4.59% decline in 2008 from the previous year.
[20] Source: http://www.chinadaily.com.cn/bizchina/2009-08/10/content_8548117.htm

be revised upwards. This would tend to lead to a larger reduction in energy intensity than shown in the table. The upward revision to GDP in 2008 was 4.4%. If the same pattern of distribution of that increase is used as for the First Economic Census (for 2004, released in 2005) the effect would be to increase the growth of GDP between 2005 and 2008 by about 1.2%, and reduce energy intensity by a similar amount.

Secondly, the energy consumption figures for 2008 and 2009 also reflect the results of the Second Economic Census, which had a special focus on energy use. The effect was to increase the level of energy use in 2008 from 2.85 MT SCE to 2.91 MT SCE (an adjustment of 2.1%), so as to put it 9.6% higher than in 2007, if the 2007 figure is taken as unchanged (as the current CEIC tables do). The basis for the energy data in Figure 11 is the previously published levels of energy use in 2005-07, together with the new levels for 2008 and 2009. But it is quite likely that the higher 2008 estimate for energy use will also lead to higher energy use in earlier years (2005-2007). An upward revision to energy use in 2005 (perhaps of up to 1%) would again lead to a larger reduction in energy intensity than shown in the table.

Thirdly, the published figure for energy use for 2009 (3100 MT SCE, or a 6.5% increase on 2008) is preliminary, and may well be revised upwards. The accompanying data indicate that energy use based on fossil fuels rose by 9.2% in 2009, and that energy use from renewable sources (which is still mainly hydro) fell by 21.4%.

Fourthly, both Minister Xie Zhenhua and Premier Wen Jiabao were quoted as saying (Krishnan, 2010; China Daily, 2010) that over 2006-09 energy intensity fell by 14.38%. While they presumably have advice based on the latest data on the issues raised above, the difference between this estimate and that calculated in the table from the published data is large. The revisions foreshadowed above could lead to a bigger energy intensity reduction than calculated in Figure 11 by up to 2-2.5 percentage points, but seem unlikely to generate a figure in excess of 10% for 2006-09. There may be other issues of which we are unaware, or different calculations may be being made.

Finally, the figures for 2010 are only estimates, of course. They are based on the apparent continuation of rapid growth, but also on the fact that the published figures on coal production and on the growth of the energy intensive industries through the first two months of 2010 imply a rapid growth in energy use in 2010. Given the current pattern of growth there may indeed be little reduction in energy intensity in 2010.

The lack of reliable and consistent data on the energy intensity issue has resulted in much discussion around the ability to meet the targets and the implications of failure to meet them. According to Ma Liqiang (Global Times, 2009), China shall achieve the energy efficiency reduction of 20% by 2010 (equivalent to reducing emissions by 600 million tce) and reduce carbon emissions by at least 1.5 billion tons by 2015 (assuming from a BAU scenario). Some even suggested that the initial failure of the targets and subsequent central government criticism would ensure that local governments comply with national standards. However, it is increasingly apparent that the 2008 stimulus package has witnessed a return to the earlier pattern of rapid economic growth driven by investment in energy-intensive industries.[21] In early 2010, Tsinghua's Hu Angang argued that China would be lucky to reach a target of 10% considering the figure was around 8% on his estimates. Hu's conservative estimates are correlate with estimates made by ANU's Howes (2010) of around 8.2%. Earlier in 2009, Lin Boqiang, director of Xiamen University's Energy Economics Research Center countered that "with all signs pointing to strong demand growth going into the second half [of 2009], the government's target … is becoming more unlikely. Instead a reduction of 15% to 16% is more realistic".[22] According to Professor He, the director of Tsinghua University's Low Carbon Energy Laboratory, this figure is still a very significant achievement for any country in the midst of industrialisation (Seligsohn, 2009). Naughton (2009a, 4-5) argued that the stimulus has actually 'distorted the Chinese economy by halting, and temporarily reversing, the decades-long trend for the state to retreat from the economy, and for private and non-governmental actors to play a greater role'. This has a dual effect of both reducing efficiencies and undermining the incentive structure for public and private decision-making. As such, the stimulus may have broader implications beyond energy use to affect the economic rebalancing program.

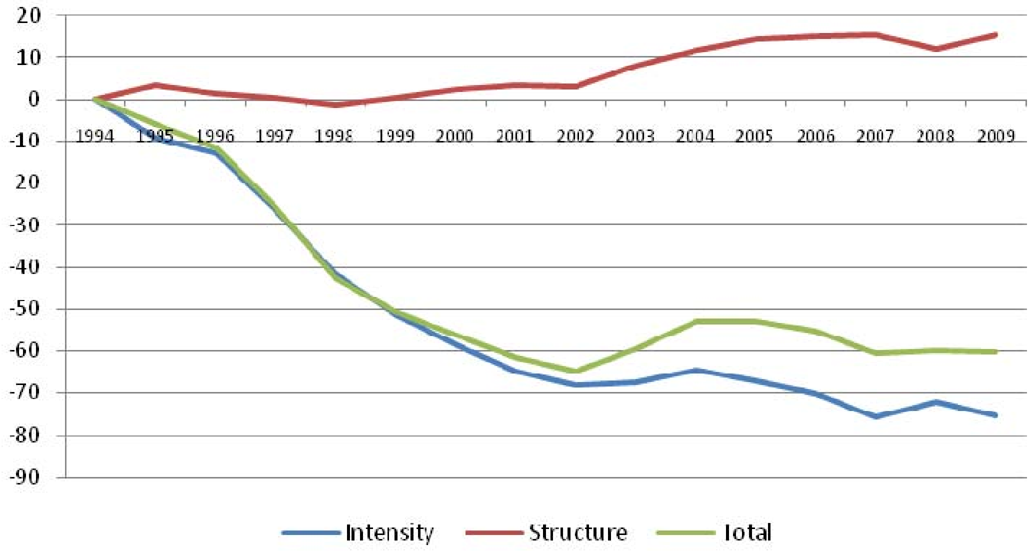
Presently, it remains difficult to quantify much of these issues until more detailed national and sectoral energy usage data for 2008 and 2009 are publicly available in early 2010. What is clear however, is that deep structural economic reforms are required if China wants to curtail energy demands and the resultant carbon emissions.

Analysis of national energy intensity and elasticity data against GDP alone is not however a reliable measure of energy efficiency. Using energy intensity as a measure of efficiency requires consideration of: the structure of GDP, in terms of the relative importance of high and low energy intensity industries within the economy (*the structure effect*); and the intensity of energy use per unit of value added within individual industries (*the energy intensity effect*).[23] The full implications of these effects are highlighted by examining the period 1994-2009, and particularly the period since 2001.

One key result of this intensity and structural analysis is summarised in Figure 12 below, which shows contributions to changes in China's overall energy intensity, in terms of energy use per unit of real GDP, over the period 1994-2009.

[21] According to Xie Zhenhua, NDRC vice minister, China may reduce its energy consumption per unit of gross domestic product (GDP) by 5% in 2009, but he cautioned about meeting the 20% cut by 2010 (Xinhua, September 27: http://news.xinhuanet.com/english/2009-09/27/content_12116602.htm).
[22] http://english.caijing.com.cn/2009-08-04/110220301.html
[23] Additional considerations include: China's geography in terms of its size and climate whereby China typically has a higher demand from the transport sector and climate determines the demand for heating or cooling; the value and fluctuations in exchange rates can affect analysis of energy efficiency; and, China's general energy mix and historical access to energy resources.

Figure 12: Intensity and Structural Contributions to the Change in Aggregate Energy Intensity, China, 1994-2009 (thousand tons of standard coal equivalent per billion RMB at 2005 values)



Source: NBSC, 2010; CEIC database and estimates of the authors (for details see Appendix)

In 1994 China's aggregate energy intensity was 175,500 tons of standard coal equivalents per billion RMB in 2005 values. By 2002 this figure had fallen to 111,700, a decline of 64,800 tons SCE per billion RMB or 37%. As shown in Figure 12, this was entirely due to declines in energy intensity within specific industries, which had contributed a decline of 68,000 tons per billion RMB to offset a rise from structural factors of 3,200 tons per billion RMB (see Figure 13). This was a period of rapid declines in energy intensity within industries, particularly energy intensive ones, which both continued the long decline since 1980 and also in part reflected emerging energy shortages. It was also a period of relative stability in the structure of GDP.

Figure 13: Sectoral Energy Elasticity and Energy Use Based Upon Primary Energy Consumption and Real Value Added, China, 1994-2007

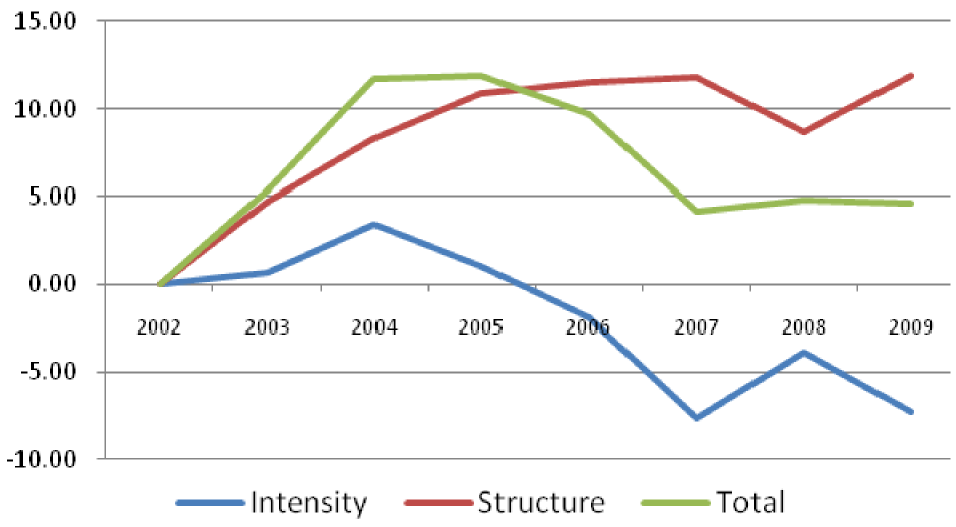
Sector	Primary energy consumption			Real value added			Descriptive statistics	
	2007 (Mt SCE)	Change 1994-2001 (% pa)	Change 2001-07 (% pa)	2007 100 billion RMB at 2005 values	Change 1994-2001 (% pa)	Change 2001-09 (% pa)	Elasticity of energy use 2001-07	Energy use/ value added (Mt SCE per 100 billion RMB) 2007
Agriculture	82.4	3.3	4.3	24.4	3.6	4.8	1.01	3.4
Industry								
Mining	140.6	1.7	4.6	11.2	11.5	11.5	0.35	12.5
Petroleum processing	131.8	11.0	9.9	2.4	8.7	13.6	0.65	55.5
Chemicals	272.5	-2.7	12.5	5.8	10.9	13.8	0.96	47.4
Non-metallic minerals	203.5	-1.3	10.1	4.9	4.0	12.8	0.88	41.4
Ferrous metals	477.7	2.4	17.6	7.5	2.8	18.0	0.93	63.6
Non-ferrous metals	106.9	6.8	17.6	3.3	12.6	20.7	0.81	32.5
Other manufacturing	369.8	-0.1	9.6	57.3	10.8	12.6	0.83	6.5
Electric power, gas and water	198.9	8.7	9.0	7.8	19.2	8.4	1.28	25.4
Total	1901.7	1.7	11.6	100.2	10.5	12.7	0.95	19.0
Construction	40.3	7.5	10.3	13.0	7.0	11.5	0.91	3.1
Services								
Transportation	206.4	9.1	12.2	13.6	10.2	11.1	1.16	15.2
Wholesale, retail and hospitality	59.6	8.5	10.6	17.6	8.3	11.8	1.04	3.4
Other tertiary (inc. households)	365.3	1.1	8.3	62.4	10.1	12.2	0.72	5.9
Total	631.4	3.5	9.7	93.6	9.7	12.0	0.87	6.7
Total economy	2655.8	2.2	10.8	231.2	8.7	11.3	1.01	11.5
Memorandum item								
Five energy intensive industries	1192.4	1.1	14.0	23.8	6.4	15.5	0.89	50.0
Industry as a share of total	71.6%			43.3%				
Five industries as a share of total	44.9%			10.3%				

Source: NBSC, 2010; CEIC database and estimates of the authors (for details see Appendix)

Since 2002 the position has been quite different, as shown in Figure 12 and more clearly (on a revised scale) in Figure 14. On our estimates[24] aggregate energy intensity is about 5,000 tons SCE per billion RMB (or 4%) higher in 2009 than in 2002. With the rapid expansion of industry after China's entry into the WTO in 2001, and with energy supplies rising rapidly, both the intensity and structural factors contributed to rising energy intensity after 2002. But after 2004 the intensity measure began to fall, and this accelerated as the policies of the 11th Five Year Plan took effect. We estimate that falling industry-specific intensities reduced overall energy intensity by 7,300 tons SCE per billion RMB or 6.6% between 2002 and 2009.

[24] The structure of China's GDP can be estimated through to 2009, but on the basis of eleven months data for 2009. Aggregate energy use for 2009 will not be available until early 2010. On the basis of a range of partial indicators, we assume that the increase for 2009 over 2008 is 8.5%. The intensity effect for 2009 is then inferred from the aggregate data and the estimate of the structural measure.

Figure 14: Intensity and Structural contributions to the Change in Aggregate Energy Intensity, China 2002-2009 (thousand tons of standard coal equivalent per billion RMB at 2005 values)



Source: NBSC, 2010; CEIC database and estimates of the authors (for details see Appendix)

The measure of the structural composition of GDP continued to increase until 2007, and then dropped in 2008 as policy makers attempted to restrain the growth in energy intensive industries. But the economic stimulus package put in place in the wake of global financial crisis has led to renewed rapid growth in these industries. As a result, China's GDP became more energy intensive in 2009, and is likely to become more so in 2010. Overall, between 2002 and 2009 the shift to a more energy intensive economic structure is estimated to have contributed 11,900 tons SCE per billion RMB or 10.7% to overall energy intensity, more than outweighing the effects of falling intensities within specific industries. It seems clear that, in moving to reduce energy intensity in the future, China needs to give attention both to changing the structure of GDP as well as to improving the efficiency with which energy is used in individual industries.

Pathways for Rebalancing the Economic Structure

These structural economic imbalances are becoming increasingly difficult for the government in Beijing to ignore, especially as the global and transboundary implications of China's developmental path increase. As such, achieving a rebalancing of the economy is receiving both enormous momentum and attention from the central leadership. In response, central government leaders have called for immediate work to adjust China's pattern of economic development towards a more equitable and balanced approach to economic development. It is increasingly clear that, in moving to reduce energy intensity in the future, China needs to give greater attention both to changing the structure of GDP as well as to improving the efficiency with which energy is used in individual industries. This section firstly provides a brief but detailed review of the structural rebalancing program within the 11th Five Year Plan before exploring the broader policy measures China has chosen to adopt to achieve the dual aims of structural rebalancing and energy efficiency. This section also highlights some of the policy issues relating to the formulation, co-ordination and progress of specific energy efficiency policies. This is followed by an examination of the potential implementation constraints (and opportunities) relating to China's governing system, its differentiated development experience and the implications of the current pattern of development relating to economic growth, population and urbanisation.

In early 2010, China's deputy Prime Minister Li Keqiang, highlighted the critical nature of structural economic imbalances, but also of the urgency to adjust the pattern of development:

> *We stand at a historic juncture, … we must change the old way of inefficient growth and transform the current development model that is excessively reliant on investment and exports.*[25]

Li's comments also reveal the resilience of the "old" economy of investment and export-led growth, which continues to defy round-after-round of national policies and exhortations by state leaders.

The serious implications arising from the imbalances within China's economic structure add up to a powerful case, largely accepted by the government, for a significant change in its current development strategy. The state announced a raft of ambitious measures for rebalancing economic development in the current 11th FYP covering energy use, air and water pollution, service sector growth, urbanization and social welfare provisions.

A summary of the limitations of the existing pattern of development together with the key dimensions of the revised development strategy during the 11th FYP are provided in Figure 15.

[25] Bennhold, K. (2010) China's Next Leader Offers a Glimpse of the Future, *New York Times*, 28 January online: http://www.nytimes.com/2010/01/29/business/global/29yuan.html?partner=rssnyt&emc=rss

Figure 15: Dimensions of China's Revised Development Strategy during the 11th Five Year Plan

Limitations of Existing Strategy	The New Strategy
Energy intensive growth	**More knowledge and technology intensive growth**
• Concentration on low value added activities • Inefficient transport and consumer energy use • High-levels of pollution and environmental degradation • Low pricing of resources and no costing of social and environmental externalities • Heavy reliance on energy and resources • Advanced technologies not available	• Become market leader in use of advanced technologies • Mandate leading transport and consumer energy use • Constraints on energy intensive activities • Target energy efficiency gains amongst top energy users & sectors • Adopt clean production & stimulate the adoption of advanced, energy efficient and more environmentally benign technologies, processes and practices • Require global companies to share advanced technologies • Diversify energy mix emphasising low carbon energy generation, such as hydro, nuclear, wind and natural gas
Focus on export oriented manufacturing	**Shift to value added production**
• Low employment growth in industry • Low wages, limited broader benefits • Big trade surplus, foreign exchange	• Gradually increase Yuan's value • Reduce preferential climate for low value exports • Market pricing for energy and other inputs • Seek greater external value adding to resource imports
Over-emphasis on investment activities	**Control over-investment**
• Excessive, unproductive investment • High energy and other resource use • Development of speculative activities	• Limitations on local government competition • Market pricing for land, energy and other inputs • Use monetary policy to vary interest rates and credit controls to avoid bubbles
Low growth of health, and other services	**Develop sources of services growth**
• Low public spending; high private costs • High savings; low consumer spending • Unequal access to basic services	• Higher taxation of incomes and growth sectors • Increased public outlays on 'soft' social infrastructure • Development of public health sector/other services • Higher employment growth, especially in services • Improve consumer and SME access to credit
Low social dividend from growth	**More employment and better services**
• High level of rural poverty despite growth • Low employment growth • Limited access/high cost of rural services • Inadequate support for migrant workers	• Improve wages and labour conditions • Promote growth and income in agriculture • Develop comprehensive system of rural health, education and other services

The 11th FYP outlines a vision of development that is socially and environmentally sustainable and that contributes to maintaining a harmonious society. It outlines broad programs to be implemented towards achieving such a form of development as follows:

- to make growth more sustainable and environmentally benign, and to reduce pollution and the rate of energy and water use;
- to increase innovation within all sectors, including industry, and shift the pattern of activity from low value added output based on low labour costs towards higher value added activities based on knowledge;

- to change the structure of growth towards the service sector, and accelerate the growth of particular service sectors that directly contribute to individual welfare; and,
- to improve rural welfare and to build structures and services that ensure the benefits of growth flow to people in rural areas.

Reinforcing these qualitative declarations are quantitative commitments within the Plan across several areas, including the economy, population, resources, environment and social services. These indicators include both mandatory and anticipatory targets based upon figures supplied on an annual basis by sub-national governments. Figure 16 includes some of the key indicators, targets and progress to the end of 2008 relating to economic structure and energy. It appears that progress to date remains modest with a lot of catch-up required to meet the 2010 targets, especially regarding the service sector's share of GDP, energy intensity improvements and R&D spending. According to the World Bank's (2008) Louis Kuijs, despite the ambitious commitments within the 11th FYP, "China has been less successful in rebalancing its overall pattern of growth, which has limited progress on many key objectives of the 5YP." The Chinese government has introduced a comprehensive set of policy measures together with monitoring and verification procedures to ensure the targets are met, which are detailed later in the report.

Figure 16: 11th Five Year Plan Targets for Rebalancing the Economic Structure

	Indicators	Status in 2005	2010 Target	Status in 2008
Economic structure	Service industry's share of GDP	40.3%	43.3%	41.8%
	Urbanisation rate	43%	47%	45.7%
	R&D per unit of GDP	1.3%	2%	1.52%
Energy & climate related	Energy intensity		20% reduction from 2005 levels	10.08%
	Rate of comprehensive treatment of solid industrial waste	55.8%	60%	62%
	National forest coverage	18.2%	20%	19%

Source: State Council, 2006a; World Bank, 2008; WRI, 2009

According to Naughton (2006, 9), the plan is remarkable:

> *There emerges from this Plan document a rich and comprehensive vision of a sustainable development process in China, and a glimpse of the kind of government role that would be required by this development process. The vision is of a society that is more creative, more focused on human resource development, and treads with a lighter and more environmentally benign step.*

The most obvious feature of the task China faces in revising its strategy is the complexity of the undertaking, given the many inter-related areas of policy that need to be considered and the vast array of public and private agencies, both domestic and international, that play a significant role in China. The six elements of the revised strategy, while quite different in many respects, are all closely interrelated with one another. Successfully implementing them requires recognition of this interdependence, and a stronger knowledge base on the factors determining current outcomes on the inter-relationships between them, as well as the analysis of policy options in this full context. For example, if energy use and environmental damage is to be reduced while allowing strong growth to continue, the structure of growth needs to change. For this to occur, the application of knowledge and technology within industry must be strengthened and service industries, such as health and education, must develop more rapidly, and reach the whole population. And yet, to realise this later point, revised fiscal and governance arrangements might be necessary. Moreover, given that the development of coordinated policy responses over many sectors and issues are likely to be critical to achieving an overall change in strategic direction, the continuing role of the planning process in China, as an instrument for strategy development and reform rather than for operating a command economy, is of considerable importance. As such, time will be required before such a comprehensive range of adjustments can be implemented in a balanced and responsible manner.

It is one thing to outline a vision of a sustainable economy and a harmonious society and quite another to define and implement a detailed set of programs to give effect to this vision. This is especially so in such a diverse, vibrant and internationally engaged society as contemporary China. The forces shaping the current growth pattern of energy intensive, investment led development are complex and inter-related, and it will take a major effort to re-align them. Given the unprecedented nature of the changes taking place in China, and their integration into complex global processes, many questions remain regarding the most effective suite of policy options as well as the speed of change required.

State Energy Policy

This section introduces the national policies, plans and laws for achieving a more sustainable use of energy.

China has always emphasised the importance of the sustainable use of energy, especially in terms of energy security and resource management. Moreover, it has achieved significant improvements in improving energy efficiency during the past three decades of economic reform. More recently, the government has enacted a comprehensive range of policy and legislative measures aimed at tackling energy efficiency, including the *National Assessment Report on Climate Change* (2003), the *11th Five-Year Plan* (2005-2010), the *Medium and Long Term Energy Conservation Plan* (2004) and the *National Energy Policy* (2004). Since 2007, several additional national administrative measures, including legislation, targets, plans, standards, codes and the establishment of relevant organisations promoting LCE-type objectives for promoting energy efficiency have been recently introduced for both specific sectors and the broader economy, including *China's National Climate Change Program* (2007), the *Climate Change White Paper* (2008), *Comprehensive Working Plan of Energy Saving and Emission Reduction* (2007) and *National Action Plan for Technology Development for Climate Change* (2007), the *Synthesizing Working Program for Energy Conservation and Emission Reduction Document* (2007) and the *Guidance for Integrated Resource Utilization (2007) and Guidance for Accelerating Energy Conservation Service Industry* (2008). The guiding policy document for China's energy policy remains the current 11th FYP.

Energy efficiency measures are covered by several national laws with the key documents a *Clean Production Law* (2002), the amended *Renewable Energy Law* (2009), the *Circular Economy Promotion Law* (2008)[26], the amended *Energy Conservation Law* (2008) as well as specific notices, codes and guidelines, including the *Strengthening Energy Conservation Evaluation and Review of Fixed-Asset Investment Projects Notice* (2006) [27] and the *Guidelines for Energy Conservation Evaluation and Review of Fixed-Asset Investment Projects* (2007).

The amended *Energy Conservation Law* (2008) shifted energy conservation to national priority status.[28] While development will remain the top policy priority of the government, the revised Energy Conservation Law states that it "implements an energy strategy of promoting conservation and development concurrently while giving top priority to conservation". The Law was initially concerned with energy conservation in the industrial sector, but later extended to the commercial and residential sectors and incorporated more detailed implementation details, such as fiscal incentives, compliance measures, standards and implementation agencies at the local and national levels. The Law refers to the need for enhancing management over energy use and adopting technically feasible, economically reasonable and environment and society-acceptable measures, in order to reduce energy consumption, losses and pollution discharge, curb waste and effectively and reasonably utilize energy in the course of production to consumption. The amended Law extended energy conservation coverage to the construction, transportation and public sector and included for the first time incentive measures for compliance (Chapter 5).

Importantly, the amended Law stipulates that all governments at or above the county level need to incorporate energy conservation work within their annual social and economic development plans, programmes and reports as well as report on progress in meeting energy conservation targets (Article 5). Moreover, the Law stipulates that local governments and local leaders are now accountable for setting and meeting energy conservation targets. Article 6 notes that the state 'will implement a system of accountability for energy conservation targets and a system for energy evaluation whereby the fulfilment of energy conservation targets is taken as one part of the evaluation of local people's governments and their responsible persons' (see earlier discuss on performance evaluation).

The earlier 1997 energy conservation law remained largely a planning document with very little acknowledgment of the significant economic shifts and resource constraints confronting China. Therefore, the inclusion of market based incentives, enforcement measures, procurement policies, taxes, subsidies, soft loans and pricing adjustment reforms for energy conservation work are important components of the amendments. These market measures have been accompanied by the introduction

[26] The circular economy refers to the combination of redesigning products with the aim of waste reduction, improving durability, promoting reuse and recycling.

[27] This notice requires after 1 January 2007, all project feasibility reports or projects application reports valued at Y500,000 and above submitted to the NDRC for approval must contain a chapter on "Energy Conservation Notice Analysis".

[28] The introduction of the amended law coincided with one of China's most devastating snow storms which resulted in the loss of power to 17 provinces and cities and a short-fall in peak power demand of around 40 million KW. It also followed the aforementioned 2007 finding by the WHO, World Bank and OECD that air pollution had caused 750,000 premature deaths from respiratory disease in China.

of specific and detailed measures and procedures by various responsible ministries, such as the NDRC, Transport, Construction, Tax and Agriculture. It appears that these responses have been successfully implemented given the improvement in energy efficiency since 2007.

The Law further stipulates that the Ministry of Construction, and its local equivalents, will be responsible for reviewing such annual energy conservation submissions. Sub-national jurisdictions and enterprises can according to the Law introduce more stringent energy conservation standards, so long as they are approved by the State Council. The Energy Conservation Law similarly stipulates that fixed asset projects need to be designed and constructed in conformity with the standards for 'rational use of energy and energy conservation design'. If they fail to comply with such standards then they cannot be put into use or operation (Article 15).

Of particular relevance to this study is the inclusion of specific requirements for residential metering of energy use at the individual household level (Article 38). Previously, energy charges were levied based on the size of the residence and therefore provided little incentive for energy conservation. The new law stipulates that new buildings and those being renovated require the installation of meters and controls for setting temperature and measuring energy use.

While the new Law provides for a significant strengthening of legal and administrative authority for improving energy conservation, the critical issue will be the degree of implementation through monitoring and enforcement. Moreover, much of the responsibility for implementation remains with local governments at the sub-national level and especially with the priorities of the local leadership (see discussion later in this report).

A new Energy Law is presently undergoing consultation and review and is expected to be considered by the National People's Congress in 2010. The Energy Law will be a 'basic law'[29] which aims to provide a comprehensive framework for better integrating the multiple existing laws, policies and notices relating to energy so as to guide the work of government and industry. The new law is expected to cover all aspects of energy assessment, exploitation, production, utilisation and management. It is expected to further prioritise renewable and low carbon energy as well as ensure energy security, including reinforcing state ownership of strategic energy interests. Energy efficiency remains the primary energy priority for China because the term is broad enough to facilitate a policy that is economic, environmentally and socially sustainable. Economically, it provides savings in reduced and more efficient energy use but more critically the term does not place a cap on total energy use.

In China, the importance of policies for increasing energy efficiency derives from concerns about: (a) energy prices, which are in themselves a reflection of energy shortages in comparison with the current levels of demand as well as social concerns about inflation; (b) energy security, which reflects the desire of every country to secure its own supply of energy over the foreseeable future; and (c) climate change, which requires a reduction in greenhouse gas emissions that are in turn a by-product of energy generation from burning fossil fuels. Clearly, the global supply of energy sources is inadequate for meeting the anticipated total energy demand. While alternative sources of energy are being developed,

[29] Basic laws typically refer to strategically important areas of public policy.

competition for fossil fuels keeps exerting pressure on energy prices. It is also clear that from a global perspective, the current reliance on fossil fuels is unsustainable and strategies need to be developed and implemented for achieving greater energy efficiency and reducing energy consumption.

Energy Policy Measures

The role of governments for increasing energy efficiency derives from the failure of market forces to include the externalities, such as pollution and waste, generated by individual producer and consumer choices. Governments can adopt policy measures to internalise these externalities, however, and can implement measures to discourage producer and consumer behaviour and influence their choices by designing appropriate incentive or disincentive structures, such as taxes and subsidies or compel them through regulation and the setting of mandatory standards or targets, so that they make choices that align with socially desirable outcomes. During the past decade the Chinese government has introduced a comprehensive suite of energy efficiency policy measures, including incentives, disincentives, regulations, subsidies, standards, targets and procurement policies. At the same time it has endeavoured to raise awareness of energy efficiency through public awareness and educational campaigns.[30] This section of the report provides a summary of some of the key policy measures the Chinese government has undertaken and provides a review of the effectiveness of these measures.

Ironically, many of these new measures were introduced at the same time that China's energy use grew at a faster rate than the broader economy. While China achieved reductions in energy use across most sectors of the economy between 1979 and 2001, since then the situation began to reverse. Firstly, China failed to achieve its initial energy efficiency targets during the 10th FYP. Then, the national annual energy intensity reductions were not met in 2006 and 2007.[31] Therefore, in an attempt to reverse this unsustainable pattern, the government has tightened up the governance arrangements. The prominence of policy measures for achieving energy efficiency were heightened following the reversal of earlier efficiency gains following the post-2001 structural shift towards industry and after Wen Jiabao became premier in 2003.[32] The ongoing failure to meet the energy efficiency targets through the 11th FYP resulted in a directive by President Hu Jintao to industry and government to strictly monitor and report energy use, prioritise energy efficiency at the highest level and the announcement that the failure to meet energy targets would affect promotion (Xinhua, 2006). In his March 2006 Work Report, Premier

[30] The program to distribute fluorescent light bulbs is a good example. It is as much an energy saving campaign as an awareness raising program. Between 2008 and 2010, 150 million energy-saving bulbs will be distributed to households saving around 29 billion kwh of electricity and removing 29 million tons of carbon dioxide out of the atmosphere annually. The program is jointly funded by the central and local governments.

[31] During the Tenth Five-Year Plan (2001-2005), the government set a target of reducing energy intensity by 15-17% (State Development Planning Commission, 2001). The failure of this target resulted in the more ambitious 20% reduction goal for the 11th FYP (2006-2010). According to comments by the Deputy Minister for Industry and Information Technology, Lou Qinjian, China failed to meet reduced energy intensity targets in 2006, 2007 and 2008 (Shi Jiangtao, 2009). In a review of GDP and energy data, China appeared to met the 2008 annual target with a 4.6% reduction but this figure was later revised down due to revised energy and economic growth figures.

[32] In Wen Jiabao's 2004 Work Report, he argues: 'The way the economy grows must change, and all industries must eliminate waste, reduce consumption of energy and raw and processed materials, and use resources more efficiently, to develop production and consumption patterns that conserve resources and build a conservation-minded society.'

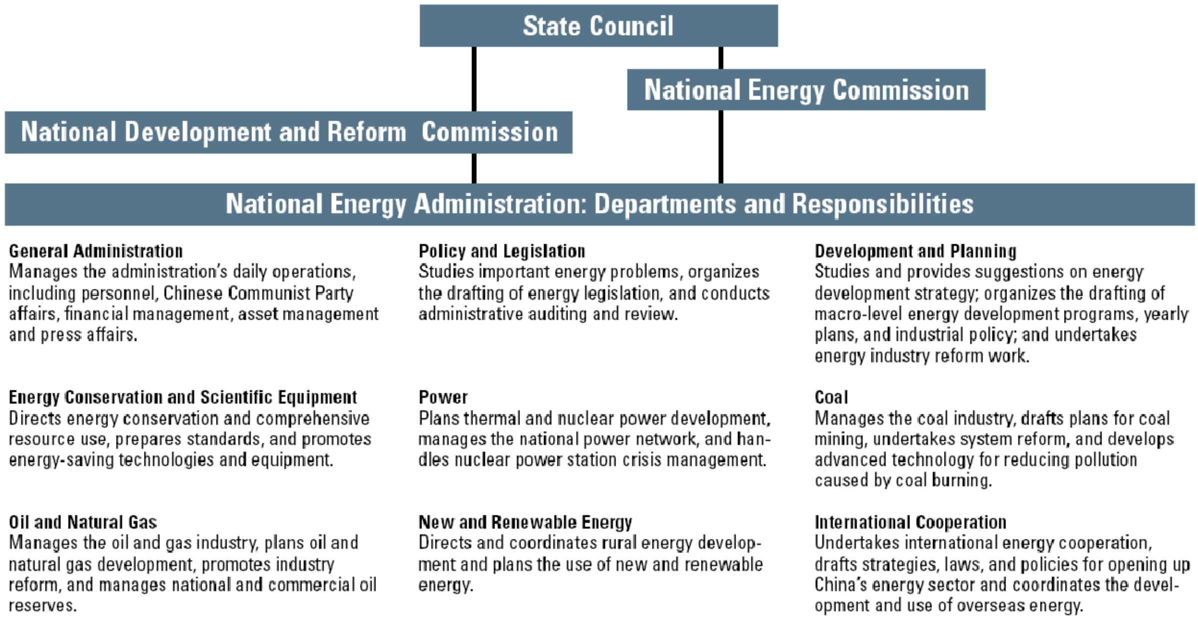
Wen Jiabao set a key target for 2006: the reduction of energy consumption per unit of GDP by 4%. This meant that, on expected GDP growth in 2006 of 8%, the increase in energy consumption would be held to 4%. However, in July the government announced that in the first half of 2006 energy consumption had risen by 11.7%, relative to the same period of 2005, on GDP growth of 10.9%, so that energy consumption per unit of GDP had actually risen by 0.8% (NBSC, 2006). As a result, the government urged all regions and departments to adopt the energy-saving target, promote structural adjustment, to focus on energy-saving in key industries and enterprises, and generally to 'make great efforts to achieve the energy-saving target for the year'. Despite all of the exhortations, the energy target for 2006 was not achieved. Therefore in 2007, the government realized it required a more comprehensive and aggressive policy approach if it was to avoid future energy policy failures. This resulted in a new sense of urgency and attention to the implementation and adoption of measures to improve energy use, especially at a sectoral level.

The importance of appropriate incentives in the implementation of public policies in China has remained a constant focus of attention (see for example, Lieberthal, 2005; Li & Zhou, 2005; Qi Ye et al., 2008). It is widely recognised that China's system of rewarding local government leaders with promotions and career opportunities on the basis of the economic growth performance of the local economies has been a strong and effective motivator of local officials. Therefore it was only time that the central government incorporated the energy targets in career promotion assessments due to the new priority for energy conservation and the earlier implementation failure. In terms of climate policy, the government has not only established mandatory targets for reducing energy consumption and the emission of CO_2 for lower level governments and for SOEs, the meeting of these targets has been made an essential part of the evaluation system for senior government officials. In a sharp break with the past, this mode of evaluation is to be used in career promotion decisions (Qi Ye et al., 2008).

Since 2008, much of the responsibility for developing, monitoring and revising these new policy approaches has fallen upon the newly established National Energy Administration (NEA), which is responsible for maintaining the country's energy supply. The NEA's responsibilities include administrating coal, natural gas, petroleum, electricity (including nuclear power), new energy and renewable energy, formulating standards for the energy industry, supervising the development of the industry, and guiding energy development in rural areas. The NEA remains under the NDRC, despite earlier claims that it would emerge from administrative reforms as a more powerful Ministry of Energy. Earlier energy policy has been plagued by coordination problems due to prevalence of "competing interest" and "splintered institutions" (Cunningham, 2007). The 2008 reforms were apparently aimed at unifying several energy related functions under the NEA. However, it seems very little has changed with energy pricing under the NDRC State Pricing Bureau and the Ministry of Commerce, oil and power firms are managed by the State Asset Supervision and Administration Commission and the MEP is responsible for energy conservation management. In a frank acknowledgement of the failure of the NEA to coordinate energy policy and apparently to strengthen Beijing's monitoring and implementation of energy policy, a National Energy Commission (NEC) was eventually set up in January 2010 after being initially announced back in the 2008 reforms (Wan Zhihong, 2010). The NEC replaces the National Energy Leading Group and as shown in Figure 17 is slightly more senior than the NEA, being led by

Premier Wen Jiabao and his deputy and aspiring leader, Li Keqiang (Downs, 2008). The NEC is tasked with formulating and coordinating energy policy, including the 20-year plan for energy, but it remains unclear if anything has really shifted (China Energy Network, 2010).[33] China is planning on establishing a Renewable Energy Centre in either 2010 or 2011 to promote the development of clean energy. According to the Energy Research Institute (ERI), the new centre will be responsible for key renewable energy projects, policymaking, international coordination, program management, market operations.

Figure 17: China's Energy Administration



Source: Downs (2008)

China's energy policy revolves are four key objectives: security of supply, economic efficiency, social equity and environmental protection (Andrews-Speed, 2004). It would be fair to say these objectives are ranked in descending order from supply security which drives policy to the lower priority of the environment. Security of supply refers to the need for adequate primary energy supplies to meet growing demand, which includes import security concerns and the domestic energy mix, as well as energy distribution and allocation. Economic efficiency refers to a gradual shift from utilising administrative and planning tools to relying on market signals for the efficient production and allocation of energy resources. Social equity considerations are however sometimes in conflict with these efficiency goals, especially the emphasis on the role of the market in terms of allocation and pricing. According to Meidan et al. (2009, 591) China's central leadership adopts a dualistic approach to energy policy by using administrative measures and controls in an effort to 'reassert control over a complex and diversified energy sector' whilst simultaneously maintaining the rhetoric for 'increased marketization of the energy sector'. Some tension remains because administrative mechanisms, rather than market-

[33] There is very little obvious difference between the NEC and the NEA, except that the former will not include the NBSC; a noticeable omission given the problems in recent years with transparency and availability of energy consumption data. On a more critical note, one observer noted that the presence of the Premier almost guaranteed that "nothing concrete would be done" (SCMP, 2010).

based measures, continue to take precedence in the design of policy implementation. At the same time, administrative measures such as state pricing controls remain important considerations in protecting certain sectors vulnerable to readjustment as well as maintaining social and political stability, especially in rural areas. Environmental protection is starting to play a more important role in energy policy, but only so far as it complements the preceding three objectives.

Industry-Specific Energy Efficiency Targets & Industrial Consolidation

The government has focussed most of its energy efficiency policies on the industrial sector, especially in the energy-intensive sectors of coal, petroleum, refining, power, steel and cement production. Current policies are pushing through reforms including industry-specific energy consumption standards, differential pricing for energy-intensive industries, industrial consolidation, mergers and the closure of small, inefficient industrial and power plants as well as the retrofitting of energy conservation devices. The justification for these policies was due to the sector's preeminent position as the largest energy user because the nation's industrial plant and equipment were generally energy-intensive, highly-polluting and wasteful as well as provided the greatest opportunities for GHG abatement. For example, analysis of the energy intensity of 13 key Chinese products in 2000 (Yusuf and Nabeshima, 2006, 22) revealed that they were 6-36% higher than the global average with stand out figures for steel (124%), cement (145%) and power generation (125%). Since 2005, production figures of these key energy intensive products continued to boom, whilst the measure of energy intensity has actually declined, but only slightly (Jiang Bing et al., 2010).

Several recent industrial energy efficiency policies introduced in 2006 and 2007 include the central government's "Top 1,000 Energy Enterprises Monitoring Program', '10 Industries Reform Plan', new energy consumption standards for specific industries, differential pricing for energy-intensive industries and the introduction of an approval process for new projects based upon an energy efficiency standard. The aim of these programs is targeting waste and overcapacity through the restructuring, consolidation, technological upgrading and closure of energy-intensive industrial sectors. The key sectors include the chemical, petrochemical, shipping, iron and steel, automobile and textiles amongst others. Smaller industrial plants in the energy-intensive sectors of cement, steel, non-ferrous metals and chemical industries have been specifically targeted for closure. Specific details include the target of closing down 15 million kW of power-generating capacity in small coal-powered plants, as well as obsolete industrial capacity in the iron (10 million tons) and steel (6 million tons) industries in 2009.[34]

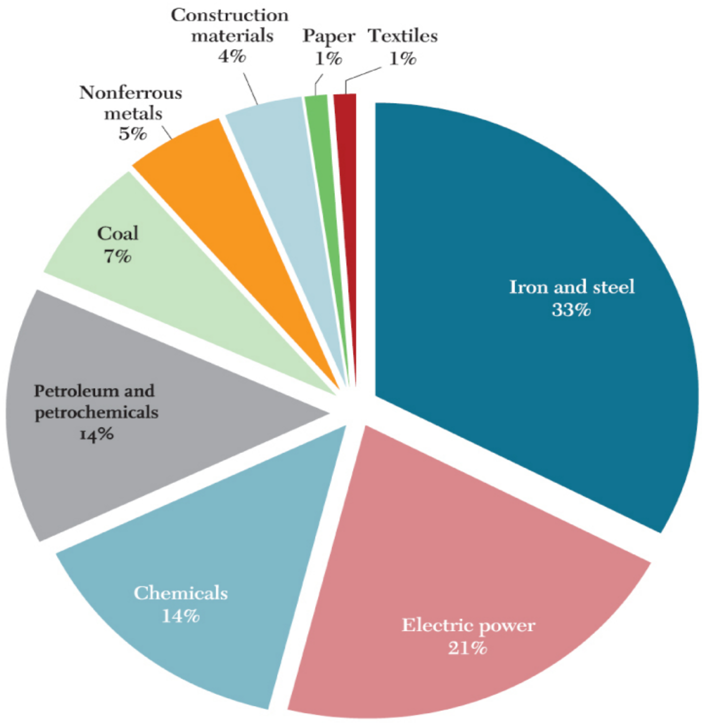
The industry-specific energy consumption standards apply to 22 major industries, including power generation. The mandatory minimum standards are based upon energy use per unit of output, type of plant and fuel or electricity consumption. For instance, the cement industry standards are measured against power consumption per ton of cement. The standards apply to existing and new facilities and are analysed according to plant size, region and type. Additional recommended and target energy efficiency standards are also provided to industry to encourage them to make the necessary upgrades to production process and plant and equipment.

[34] Source: http://news.xinhuanet.com/english/2009-05/20/content_11403629.htm

Of the 22 industries faced with energy standards, eight of the most energy intensive have been forced to pay higher energy prices based upon their efficient use of electricity (State Council, 2006b). The eight industries include: electrolytic aluminium, ferroalloy, calcium carbide, caustic soda, cement, steel, phosphorous and zinc producers. Less efficient plants classified as “eliminated” or “restricted” under the original 2006 circular faced an incremental electricity surcharge commencing from RMB0.02 per kWh and gradually rising to up to RMB0.20 per kWh by 2008. The incremental nature of the system was to encourage industrial firms to make the necessary adjustments to their plant, equipment and processes.

The “Top 1,000 Energy Consuming Enterprises Monitoring Program” is a key component of achieving the 20% improvement in energy efficiency and was introduced in 2006 by the NDRC.[35] The program targets China’s 1000 most energy-intensive enterprises, which are mostly involved in heavy industry (see Figure 18), such as iron and steel, electric power, chemicals, petroleum, non-ferrous metals, coal mining, construction materials, textiles, and pulp and paper. This five year program (2006-2010) aims to abate 100 million tons of coal equivalent (mtce) and encourage China’s industry to adopt world’s best practice plant and equipment. The 1000 enterprises in the program were chosen in 2005, because in 2004 they consumed 673 Mtce (18.7 Quads, 19.7 EJ) of energy; emitted around 43% of China’s carbon emissions; and, accounted for 33% of total primary energy demand and almost half of industrial energy demand (Price et al., 2009).

Figure 18: Energy Consumption amongst China’s Top 1000 Enterprises (% by sector)



Source: NBSC, 2007 cited in Seligsohn et al., 2009

[35] This program was modelled on the successful Shandong Province Voluntary Agreement pilot project which had been running since 2000 (Price et al., 2003).

Progress was made in achieving the annual targeted reductions in 2006, 2007 and 2008 when they were exceeded in each year.[36] Moreover, some provinces, such as Jiangsu, Shandong and Guangdong, have extended the program to the provincial level to increase the programs coverage and effectiveness. The program includes a mixture of incentives and penalties with soft loans, rebates and tax breaks to industry for investment in energy efficiency measures followed up by assessments and audits with compliance enforced by incorporating goals into the performance evaluation and promotion system for local government officials.

The 'Top 1000' program has been supported by a range of additional national programs targeting energy conservation within the industrial sector. For instance, the *Consolidation and Closure Plan* for China's major industries targets the phase-out of small-scale and outdated production capacity, the advancement of technological levels, and energy conservation and pollution reduction. In May 2009, the NDRC announced a further RMB2.5 billion for the Top Ten Energy Conservation Projects focussed on energy efficiency, emissions control and the circular economy based upon agreements between government and industrial enterprises. This is the key measure for ensuring the 20% reduction in energy intensity is reached by targeting coal-fired industrial boilers, cogeneration units and residual heat, motor systems and petroleum production. Supportive policy measures include regulations, standards, low-interest loans, subsidies and a preferential tax regime. The Circular Economy Law (2004) focuses on reducing waste, increasing productivity and achieving social, economic and environmental targets in line with the principle of reduce, reuse and recycle on a lifecycle basis. In 2009, the Circular Economy Promotion Law was introduced to provide more detailed supervision and compliance measures, particularly in the energy and resource-intensive industrial sectors.

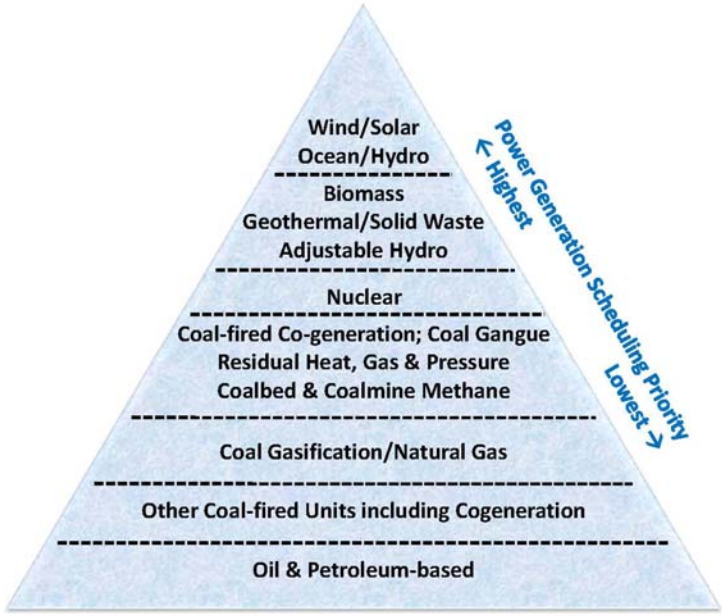
Since 2006, the central government has closed down small inefficient thermal power plants in order to achieve the 20% reduction in energy intensity through two programs: (i) Large Substituting for Small (LSS) and (ii) Energy Conservation power generation dispatching or scheduling (EC scheduling). These programs aim to remove 114 GW of small power generation units from operation. Under this scheme power companies planning on expanding power generation or building new thermal plants, for example, will need to first close less efficient plants before they are eligible to receive NDRC permission and support for purchasing new super critical coal units. The LSS program expects to decommission about half of China's existing inefficient thermal power plants below 100 MW between 2006 and 2010. By early 2009, 54 GW of small, inefficient coal plants had been closed.

In a step towards increasing transparency and public monitoring of the closure, the closed plants and units are publicly listed online to ensure they remain closed. The government shall then utilise the complementary EC scheduling program to gradually phase out the remaining units by prioritising the scheduling of power generation towards low carbon power generation from renewables, nuclear, efficient and cleaner coal power plants (Tian, 2008). This program has been piloted in several provinces since 2007 and is aimed at developing a market mechanism for phasing out the existing even load power

[36] A NDRC (2008) assessment found that 90% of the key industrial enterprises met the agreed energy efficiency targets.

generation scheduling rule with a new system that prioritises low carbon sources of energy generation.[37] The priorities of energy generation are detailed in Figure 19 and range from renewable energy at the top with petroleum-based energy at the bottom. The program includes additional sub-category priorities based upon energy efficiency, emission levels and water usage. Units can only be scheduled for generation once all high priority units have been utilised. It is envisaged that this system if successfully on a national level will provide the largest energy savings in the power sector, although there are no data available of estimated abatement or savings.

Figure 19: Hierarchy for Energy Conservation Scheduling (ECS)



Source: State Council, 2008

Consolidation and closure are being used as a key measure within each of the key energy intensive sectors, notably steel (see Figure 20).[38] According to the Ministry of Industry and Information Technology (MIIT, 2009), steel plants need to meet a minimum production capacity of 1 million tons, or 500,000 tons for specialized steel makers. Otherwise they face forced merger or closure. Plants also need to meet minimum energy consumption levels of 411 kilograms coal equivalent per ton of steel. In addition, for each ton of steel produced, mills cannot use more than 6 tonnes of water and their pollution emissions cannot exceed 2m^3 for waste water and 1.8 kg of sulphur dioxide. At the same time, the steel industry reportedly rejected RMB200 billion worth of new steel projects in 2009 and is

[37] The scheduling system could be perceived as a precursor for the introduction of a carbon tax as it provides a quasi-market mechanism to replace the existing current even load power generation scheduling.

[38] Following large losses by the two of the world's large steel producers, ArcelorMittel and Baosteel in 2009, China reportedly called for a focus on quality over quantity due to fears of steel overcapacity and economic losses (Bloomberg, 2010). Initially, draft consolidation plans called for the creation of one or two large steel producers of around 100 million tons annually. However, this may be revised down to around 50 million tons. There are also growing concerns within the steel sector that the consolidation program is biased towards the public sector (Naughton, 2009c).

planning to close plants that remain too inefficient. However, the NDRC remained concerned about the slow pace of consolidation and reform within the steel industry against the release of steel production figures for 2009 of 568 million tons, which is up 14% on 2008 (Bloomberg, 2009)

Between 2006 and June 2009, China shut down 54 GW of inefficient less than 100 MW coal plants and plans to shut a further 31 GW by 2012.[39] Plants under 200 MW are then set to be targeted for closure leading up to 2020. At the same time, a regulation for newly installed coal-fired power plants to be most advanced power plants (Super Critical Units, Ultra-super Critical Units) was introduced in 2007, resulting in China becoming "the major world market for advanced coal-fired power plants with high-specification emission control systems" (IEA, 2009c). Additional studies confirm the transformation of China's coal power plants from world's dirtiest to the most efficient (Zhao Lifeng et al., 2008; Steinfield et al., 2008; Greenpeace, 2009). In 2009, it was announced that China's top-ten energy companies all met the 2010 target of 355 grams of coal per KwH of coal power generation. In 2009, the average efficiency of China's coal-fired power plants was around 339 grams of coal per kilowatt-hour. The average in developed economies is around 330 grams. However, China's ulta-supercritical coal plants are reportedly using only 300 grams and one new Shanghai plant achieved a world leading efficiency of only 282 grams (Xinhua, 2009a). This is a marked improvement in the energy efficiency of China's coal power plants which burnt an average of 448g per kWh in 1980 and 400g in 2000.

Figure 20: National Planning Targets for the Closure of Energy Inefficient Capacity in Small Industry

Sector	Action	Unit	Capacity reduced during 11th FYP	Already closed in 2007
Power generation	Replace small power plants with large ones	GW	50	10
Iron making	Closure of blast furnaces with size smaller than 300 m3	Mt	100	30
Steel making	Closure of small convertor and electric arc furnaces with capacity smaller than 200 kt	Mt	55	35
Electronic plating	Closing small equipment	1,000 tons	650	100
Iron alloy	Furnaces smaller than 6,300 kVA	1,000 tons	4,000	1,200
Calcium carbide	Furnaces smaller than 6,300 kVA	1,000 ton	2,000	500
Coke	Small coke kilns with height less than 4.3 m	Mt	80	10
Cement	Replacing machinery, vertical kilns	Mt	250	50
Glass	Closure of old technology	1,000 cases	30,000	6,000
Paper making	Straw pulp plants with capacity smaller than 34 kt, chemical pulp plants with capacity smaller than 17 kt	1,000 ton	6,500	2,300

Source: ERI, 2009

It is difficult to ascertain the long-term effectiveness of the policy measure of closure as detailed in Figure 20 due to local resistance and weak compliance. Traditionally, local governments enforce closure during a political campaign, but then reopen operations once demand picks up and the attention of the central government shifts elsewhere. At the sub-national level, leaders who are driven by development oriented targets and incentives for promotion are often involved in the financing and under-reporting of power producing capacity that is forbidden by the central government. According to a recent report, Chinese government sources have estimated that approximately 120,000 MW of electric capacity

[39] See Tian Jun, 2008.

currently in the process of installation had not received approval from Beijing and is, therefore, illegal (Cunningham, 2007). The fact that this installed capacity is 'illegal' does not mean that the plants are hidden in a closet or that they lack any governmental oversight. Instead, it means that the plants are not part of a coherent national policy, and that they frequently operate outside national standards. These plants were obviously all financed, built and put into service, but nobody at the central government level can be sure under what terms or according to what standards. 'The key to understanding how this could happen lies in the local government role' (Lester & Steinfield, 2006).In an attempt to reduce local resistance and the reopening of closed plants, the government is using transparency measures, such as public monitoring by posting the details of closed plants online .

A key component of policies targeting large energy users is the sectoral-based energy intensity targets (introduced earlier in the report). These targets are part of the government's broader industrial production goals encompassed within the *Energy Conservation Plan* for different sectors, including steel, non-ferrous metals, cement, oil refining, power generation, plate glass, chemicals, etc. This plan and subsequent documents have set energy intensity targets per unit of production for 2010 and 2020. In contrast to the slow progress on energy efficiency gains, it seems likely, as illustrated in Figure 21, that the energy intensity targets for major industrial sectors will be met.[40]

Figure 21: Energy Intensity Targets for Key Industrial Products

	2000	2005	2010 Targets
Thermal Power (gce/kWh)	392	370	355
Steel (kgce/t)	784	700	685
Aluminium (tce/t)	9923	9595	9471
Cement (kgce/t)	181	159	148
Ethylene (kgce/t)	848	700	650
Railway transportation	10.41	9.65	9.4

Source: NDRC, 2004; WRI, 2009

Reducing energy intensity requires attention beyond industrial sectors to also include regional disparities. In September 2006, the government announced the system for achieving the 20% improvement in energy efficiency with differentiated allocation targets for each province (see Figure 22). Energy efficiency targets were weighted towards provinces with high carbon intensity levels and the targets included details and identified areas for low-cost improvement. For example, Jilin Province needs to reach a 30% reduction in energy intensity by 2010 and yet its energy intensity figure is half of Guizhou Province. If all the provinces are able to meet the targets by 2010 and GDP growth averages 9.9% then it will result in a reduction of 3.39 billion tce or around 25% higher than the national target of a 20% improvement.

[40] Perhaps as an outcome of the state's reforms, energy intensity figures during the first half of 2009 declined in several key industrial products: 8.43% within the steel industry; 3.83% in the coal industry; 19.59% in non-ferrous metals; and 9.51% in power production. Source: Xinhua http://news.xinhuanet.com/english/2009-08/02/content_11813538.htm

Figure 22: Differentiated Energy Efficiency Targets during the 11th Five Year Plan

	2005 Base calculation	2010 Target	Reduction		Region	2005 Base calculation	2010 Target	Reduction
	tce/RMB10,000		%		Unit	tce/RMB10,000		%
National	1.22	-	20		Jiangsu	0.92	0.74	20
Beijing	0.80	0.64	20		Fujian	0.94	0.79	16
Shanxi	2.95	2.21	25		Shandong	1.28	1.00	22
Inner Mongolia	2.48	1.86	25		Guangdong	0.79	0.66	16
Jilin	1.65	1.16	30		Chongqing	1.42	1.14	20
Shanghai	0.88	0.70	20		Guizhou	3.25	2.6	20

Note: 2005 constant values Source: CEACER, 2009

The Chinese government utilises a combination of planning and market measures to achieve energy conservation and improve energy efficiency gains including targeted taxation, subsidy and rebate programs. The government has extended a series of subsidy programs that were initially introduced as part of the November 2008 stimulus package into 2010 for the purchase of household appliances and motor vehicles. For example, an initial 'cash for clunkers' program lifted funding from RMB3-6,000 per vehicle over 10 years-old to RMB5-18,000. The reduced sales tax for 1.6 litre or smaller vehicles was also extended through to the end of 2010, but it was lifted from 5% to 7.5%. Additional support for more sustainable energy use in motor vehicles included a joint transport policy calling for subsidies to new energy vehicles, which was released in early 2009 by the Ministry of Finance, the NDRC, MIIT and the Ministry of Science and Technology. Proposed subsidies under the policy are to range from RMB4,000 to RMB600,000. It is expected that this subsidy will be extended to private purchases of new energy vehicles in 2010, but may be limited to the pilot cities and their respective local vehicle manufacturers.[41] A rebate program was also extended in 2010 for the purchase of energy efficient household appliances, such as Grade 5 air conditioners. To further boost rural incomes, the price cap on eligible products has been raised in rural areas. The combination of the subsidy and the lower taxes have been behind a surge in consumer spending, especially sales of motor vehicles with smaller vehicles contributing to 85% of the growth in sales for 2009 (China Daily, 2009). Additional state subsidies are aimed at promoting renewable energy with a feed-in tariff for biomass, wind and solar energy, including a RMB20-a-watt subsidy for solar projects, covering about half the capital cost. In 2009, the feed-in tariffs per kilowatt hour is set at RMB0.51, RMB0.54, RMB0.58 and RMB0.61 or about double the average kilowatt hour rate of RMB0.34 paid to coal power generators. Despite the tariff and recent reduction in the cost of

[41] According to the vice minister of MIIT, Miao Wei, a progressive subsidy system would be allocated for new energy vehicles based upon the degree of technological sophistication involved. Miao noted that the program would be aimed at "encouraging technological innovation" (Liang Dongmei, 2010). Miao also mentioned that the subsidy would be temporary to assist companies in developing the initial capacity and market share before returning to cost benefits. According to a Nanfang Daily (Chen Zhijie, 2010) report, a nation-wide rollout of new energy vehicle subsides is not likely. Instead, the subsidy program will be restricted to supporting local motor vehicle manufacturers. For example, Shenzhen Municipality is allocating subsidies for BYD's hybrid plug-in F3DM vehicles (interview with authors; Li Fangfang, 2009) and Chongqing Municipality announced that it will be only allocating them to Chang'an Motor's hybrid Jiexun vehicle (Reuters, 2009).

renewable energy production, wind power remains around 30% more expensive than coal power and solar is double the cost.

In addition, the government has introduced gradual reforms to energy and resource prices, as well as provided direct government investment on energy saving projects, such as the installation of heat pumps or cogeneration facilities. During 2009, diesel and gasoline prices were increased four times and coal prices were also increased. However, concerns about social stability are intricately linked to resource prices as are inflation and exchange rate shifts. A renewable energy fee is slowly reducing the gap in electricity generation costs between coal and renewables by charging electricity users, both residential and industrial, a 4% and 8% fee on their respective bills. The revenue is allocated to the grid operators to reduce the disparity in costs between coal and renewables.

The size and rapid growth of China's energy industry will continue to bring prices down by reducing the reliance upon imports, but also facilitate large scale manufacturing.[42] Moreover, the government utilises its significant budget and public works programs to procure and promote energy efficiency products, technologies and systems. Government procurement programs can play an important role in advancing the commercialisation of emerging developments. The new energy vehicle program includes 20 city governments procuring at least 1,000 hybrid and electric vehicles to assist car manufacturers in moving towards the 500,000 new energy vehicle figure for 2012.

Reforms to the tax system have played a part in not only increasing government revenue, rebalancing fiscal allocations between the central and local governments, but also in shaping production and consumer behaviour. In terms of energy and resource use, China's tax system includes several components, which have been readily adjusted in recent years in order to achieve energy conservation. Adjustments to VAT rebates have been used to promote investment and sale of wind turbines and solar PV. Since 2008, the wind generation sector has received a major boost with its VAT reduced from 17% to 8.5%, its income tax cut from 33% to 15% and direct government investment for the installation and feed-in tariffs for wind energy projects utilising at least 80% of domestic components.

In addition, some of the perverse resource and energy subsidies, taxes and rebates have been removed in recent years, including reducing the tax rebate for the export of energy intensive production and the subsidised differentiated energy prices for key energy-intensive industries. Due to relatively lower levels of energy efficiency in China's industry, they remain highly sensitive to adjustments in inputs, such as exchange rates, the price of materials and electricity. Resistance from the provincial levels to price increases has even resulted in non-compliance (Seligsohn et al., 2009). Similar concerns have arisen at the sub-national level and within industry groups following public debate over the introduction of a fuel tax, an environmental tax and a carbon tax.[43] According to Jiang Kejun (2009), a carbon tax is a possible

[42] In 2009, China became the world's largest manufacturer of wind turbines. While the growth in China's wind turbine industry has brought down prices and facilitated the massive expansion of wind power generation, it is unclear if these benefits will be spread globally due to protectionist concerns, especially in Europe and the US (Zeller & Bradsher, 2009).

[43] In August 2009, it was announced that the Ministry of Finance, State Administration of Taxation and Ministry of Environmental Protection have been jointly working on the introduction of an environmental tax

national policy, which could be introduced as soon as 2011 at an introductory level of around RMB10-20 per ton of carbon. Naturally, such a tax would result in increased energy and transport costs for consumers. One estimate expected the cost to be around RMB440 annually per person (AFP, 2009). At this stage, it is unlikely that a carbon tax will be introduced nationally until at least 2015 after its preliminary trial implementation in several pilot cities and regions. Moreover, a carbon tax is seen as somewhat premature prior to the government completing pricing and market reforms within the resources and energy sectors. Instead, the 2009 introduction of a RMB1 tax per litre of fuel was seen as offering an alternative approach to reducing fuel demand with Jiang Kejun (2009) estimating it could reduce fuel demand by 10% if it was set at around RMB2.4 per litre.

Energy efficiency standards and labelling programs emerged in the 1980s and have become an increasingly popular tool for achieving energy conservation in the transport, building and consumer appliance sectors. The mandatory energy standards and labelling systems cover most household appliances and motor vehicles, and are a key program for achieving energy savings across the consumer sector. By 2008, China had introduced a third catalogue of energy efficiency labelling for consumer products including a comprehensive publically-available energy efficiency database across 23 product categories. Analysis by Lawrence Berkeley Labs (LBNL, 2009) estimated that China's current labelling and standards program will reduce carbon emissions by 9.1 billion tons between 2009 and 2030.[44]

Renewables and Low Carbon Energy Generation

Tackling energy utilisation and demand-side energy issues remain crucial for China in making headway in energy conservation. Another important aspect is China energy generation mix, especially the need to break the dominance of coal and promote alternatives. One area that is expanding at a relatively faster pace than the development of coal-fired power is the low carbon sector, such as nuclear, natural gas and the renewables. Renewable energy sources, mainly hydro, wind, biomass and solar are experiencing strong growth. A major boost in renewable energy capacity in China has come from government policy measures, including subsidies, incentives, soft loans, local government renewable energy targets and regulatory provisions as well as the rapid growth in demand from outside China.

The *Medium-to-Long-Term Development Plan for Renewable Energy* (State Council, 2007) provided the initial guidance for expanding wind, solar, hydro and biomass energy generation capacity. The Plan was backed up with RMB3 trillion in funds and additional policy measures to stimulate the development and increased utilisation of renewable energy to 10% by 2010 and 15% by 2020. Specific targets for renewables included: 300 GW of hydropower; 30 GW of wind power (including several 1 GW wind farms); 30 GW of biomass; 1.8 GW of solar power; 300m^2 million coverage of solar hot water heaters; 44m^2 billion of annual methane gas utilisation; and 50 million tons per year (tpy) of biofuels. To achieve the government's ambitious target of increasing renewables in the energy mix to 15% by 2020, RMB300

(http://www.chinadaily.com.cn/bizchina/2009-08/31/content_8637587.htm). It was suggested that such a tax could be introduced by 2010. Criticisms arose however due to recent increases in fuel costs and the introduction of a fuel tax.

[44] Standards for the transport and building sector are addressed in more detail in the separate Case Study Final Report.

million was allocated between 2006 and 2008 by the central government in subsidies, mainly to support biomass and wind energy production.

The Plan was supported by the introduction of the Renewable Energy Law (2006), which was further revised in December 2009.[45] The Law offers a comprehensive national framework for renewables encompassing planning, grid connection, resource audits, fiscal and taxation measures, technology research and development, as well as education and public awareness. The Renewable Energy Law requires state grid and natural gas companies to prioritise power distribution generated from renewable energies, develop and implement emerging technologies, such as smart power grids and energy storage, improve the management and operation of the power grid and facilitate the grid connectivity and utilisation of renewable energies (Article 14). In addition, the law details the requirements for the development of, and monitoring system for, sub-national renewable energy development and utilization plans as well as penalties for non-compliance of the above measures. Failure to comply with the renewable energy components is met with a penalty regime of double the cost of the renewable energy.

Additional policy measures include preferential financial and tax policies, specialised funds subsidising the development of renewable energy sources, zero interest loans, the reduction or elimination of taxes for certain qualified renewable energy development activities and feed-in tariffs. The Plan required electricity grid companies to source at least 1% of electricity from non-hydro renewables, and medium to large power companies to source 3% of installed capacity from non-hydro renewables by 2010. This percentage would increase to 3% and 8% for grid and power companies respectively by 2020.

In 2009, several new government programs supporting renewables have been launched to accelerate the manufacture and installation of renewables. One of these programs, the *Golden Sun* initiative, provides half the cost of installation and power transmission costs for 275 new solar power stations. Remote off-grid solar power projects are eligible for subsidies up to 70%. The plan is designed to meet the dual goals of boosting local Chinese solar power manufacturers and connecting up 2 GW of installed solar capacity by 2011. Under the national renewable energy program encompassing the *Riding the Wind Plan* and the *Brightness Project*, rural and remote communities are eligible for financial and technical support for off-grid wind, biomass and solar renewable technologies (Zhang Lixiao et al., 2009).

As a result of the strong government support, China's ambitious program of renewable energy targets continue to be updated and expanded in recent years. As a result, the State Grid Corporation of China (SGCC) announced that the goals in the 2007 Plan would be exceeded with renewables actually reaching 17% of total installed capacity. The annual doubling of wind power capacity between 2005 and 2008 is testament to the success of the government programs and market demand. Since 2001, newly installed wind power capacity has grown at nearly 50% through to 2009, when a further 8 GW were added. China is currently developing a renewable or low carbon energy investment plan worth an estimated RMB3-4.5 trillion over ten years to further support the development of low carbon energy. It remains unclear how the funds will be distributed between nuclear, hydro, wind, biomass and solar generation capacity.

[45] http://www.chinanews.com.cn/ny/news/2009/12-26/2040229.shtml

Some of the initial details are also included in the "Emerging Energy Industry Development Plan" [46] which calls for:

- hydro power generation to retain its leading role with a commitment to 300 GW by 2020;[47]
- solar photovoltaic (PV) capacity to reach 2 GW by 2011 and 20 GW by 2020 which is up from the previous target of 1.8 GW by 2020; and
- wind to reach 35 GW by 2011 and 150 GW by 2020.

Figure 23: Government Energy Capacity Targets (gigawatts)

	2009 capacity	2011 target	Updated 2020 target	Original 2020 target (2007)
Solar	0.3	2	20	1.8
Wind	20	35	150	20
Nuclear	9	12	70-86	40
Hydro	150	-	300	270
Natural gas	4	36	50	70

Source: WEFN, 2009; CEACER, 2009[48]

This plan also focuses on so-called low carbon energy generation, particularly nuclear. China currently has 11 nuclear power reactors in operation with a total installed capacity of 9.1 GW or around 2% of total installed capacity. In addition, a further 24 new nuclear plants are currently awaiting approval or under construction, mostly in eastern coastal areas. When these plants come online, China's total nuclear generation capacity will reach around 25.4 GW. It is currently, expected that nuclear power generation shall increase more than ten times from 8 GW in 2007 up to 86 GW by 2020[49] and around 100 GW by 2030 (ERI, 2009). This will increase the contribution of nuclear power to around 5-8% of total generating capacity.

It is increasingly clear that nuclear power is the preferred low carbon energy fuel for substituting coal and is most likely to receive a significant boost in the forthcoming 12th FYP. According to Zhang Guobao, the director of the National Energy Administration, China will require "at least 200 million kilowatts of nuclear generation capacity to meet the basic needs of China's future economic development". China is leading the world in the construction of new generation nuclear reactors. China currently has nine third generation nuclear plants under construction, including seven Westinghouse AP1000s and two Areva EPRs, three of which are being built in inland provinces. China also has plans to commence construction of the first "fourth generation" experimental fast reactor in 2012-13.

Another area of growth is natural gas with several major investments in the supply, transmission and distribution in recent years, including the west-east and north-south pipeline and dozens of new port terminals and storage facilities. The Shanghai government recently banned the construction of new coal-

[46] Details of the plan are discussed in China New Energy (2009).
[47] In 2008, half of the 160 GW of global hydro projects were underway in China.
[48] The targets in Figure 23 are yet to receive formal approval from the NDRC and State Council but are currently being circulated and have been widely cited in the Chinese media.
[49] An earlier announcement noted that by 2020, China plans to expand nuclear power capacity to between 40-70 GW: *China Daily* 2009 Nuke power capacity set to increase, 4 February online: http://www.chinadaily.com.cn/china/2009-02/04/content_7443870.htm

fired plants, while at the same time investing in building LNG infrastructure. In 2007 the use of natural gas increased 21% and then by a further 16% in 2008 while LNG imports increased annually by an average of 15% between 2001 and 2009.

Despite the aggressive plans for the expansion of renewables and low carbon energy, the underlying concern of the state remains with closing the gap between central-government policies, plans and legislation and action at the local level. Such implementation issues need to be resolves if China is going to effectively adjust the structure of the economy and achieve improvements in energy efficiency.

Remaining Implementation Considerations

The attempt to substantially change the structure of a large, rapidly growing economy is without precedent and is likely to prove difficult, especially in an economy still dealing with the transition from plan to market. Given the lack of precedent and the inherent difficulties, there is no established knowledge base about how to proceed and how to shape and prioritise policy options. Moreover, China's governing system is confronted by an array of complex institutional constraints, which determine the shape and direction, as well as effectiveness, of national policies at the local level. In our view five groups of factors constrain China's ability to change its economic structure rapidly:

1. The limited authority of the central government in terms of detailed implementation of many measures, and the prevailing incentives for local governments to pursue rapid industrial growth (for example, those implicit in revenue sharing arrangements).
2. The macroeconomic and pricing settings, such as relative prices for environmental cost, energy and for other resources.
3. The differentiated development experience with serious contrasts in wealth and opportunity between rich and poor, rural and urban as well as coastal and hinterland.
4. The institutional and effective market demand constraints on the rapid expansion of key service areas, such as health, employment, education and a social welfare system.
5. The combination of three 'inescapable realities': the lock-in effects of current industrial and infrastructure policies; the growing, and increasingly, urban population; and, the rising living standards of an increasingly middle class population.

This section elaborates on each of these interconnected factors and their role in weakening the strong government pronouncements on rebalancing the economic structure. Each factor is acknowledged by the government as an impediment for change, but is equally aware of the risks of adjusting policies too quickly and risking social and political instability.

Questions of Governance

China's institutional and policy system has been recently credited with the necessary attributes for tackling the difficult problem of climate change. A top-down authoritarian regime, equipped with systematic and decisive long-term planning and decision-making facilities, this argument goes, can deliver where democratic governments are dominated by short-term popular policy action. Ironically, it is the same political system that has been described as characterised by institutional and policy failures, which continue to weaken attempts to ameliorate environmental damage. According to the World Bank (2009a, 4):

Institutional and policy failures are a major cause of [China's] environmental and resource use problems. Pervasive market and policy failures, including subsidies for raw materials, weak enforcement of anti-pollution regulations, and low waste disposal fees result in low resource productivity and severe pollution. Institutional and policy reforms to remedy such failures are urgent and deserve the full attention of the government.

Rather than accept the preceding argument about systems of government, it is obvious that the Chinese government realises the urgency of the current imbalances within the structure of the economy. What separates China from many developed economies is the growing understanding of the interconnectedness of the different dimensions to the problems from a social, economic and environmental perspective as well as the critical nature of these problems. In China, there is very little room for poor policy decisions due to the serious social, economic, environmental and political constraints of the nation.

While the formulation of energy policy is largely, though not exclusively, the responsibility of the NDRC and the newly established National Energy Commission, the implementation of this policy is dependent upon its respective agencies at the provincial and municipal-levels, which are exposed to regional and local forces and interests. Moreover, compliance with national policies in China is generally weak, reflecting conflict even within central government machinery as well as among central and local governments.[50] Many of the difficult decisions concerning rebalancing the economy and the allocation of resources need to be made at the local level of government. These are the same local governments that are at the heart of what Jahiel (1994, 766) calls China's ideological battle for increasing economic growth.

When several players representing their respective constituencies are involved in policy formulation or implementation, effective co-ordination plays a crucial part in their success or failure. Ideally, all levels of government should be represented in the co-ordination forums and have equal opportunities to contribute. The establishment of the NLGCC, for example, was perceived as an administrative measure designed to achieve such coordination and consensus. However, this initiative was followed, in the typical top-down approach, by directions given to the provincial governments to establish similar leading groups and to have their prefectural and county governments do the same. The responses of the local and regional governments have been described as being essentially administrative responses (Qi Ye et al., 2008). It remains to be seen how sustainable such a policy response remains particularly if the national initiatives challenge the status quo of local economic growth. Given past experience, it is more than likely that serious gaps in its implementation may arise in the not so distant future. The development of a policy co-ordination framework is lagging behind the progress towards decentralisation and marketisation.

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[50] China's administrative structure and governance system are highly decentralised into 33 province-level regions, 333 prefecture-level regions, 2,862 county-level regions, 41,636 township-level regions, and many more of village-level regions. Not all of these regions have the same degree of autonomy in policy formulation for all public services, but the formulation and implementation of national policies throughout the country nevertheless involve co-ordination through these diverse layers of administration. While China has a decentralised, five-level governance structure, its approach to policy implementation remains essentially a top-down approach.

A key principle of best practice public policies in a large country or a diverse society, such as China, is to adopt a decentralised bottom-up approach to policy formulation. This would ensure that local and regional interests and constraints are adequately reflected in the national policies. This way of policy formulation also raises the likelihood of greater local and regional co-operation in implementation, in contrast to a policy with little local involvement, but being imposed from above.

Often, governments at the county and township level do not have either technical or financial capacity to effectively participate in the co-ordination forums outlined above. This is especially likely to be the case in dealing with climate change and energy efficiency issues, because of the technical nature of the underlying issues. Local governments generally face the challenge of low levels of technical capacity and lack of awareness to deal with climate change issues. Even if a government is willing to take action, its capacity is often a limiting factor. Implementing suitable initiatives for capacity building and for technical and financial training of personnel has been identified as crucial. For example, ERI have been active in assisting several local governments in identifying energy and resource characteristics that require attention in shifting towards a low carbon economy.

The widespread practice of weak compliance and local resistance to central government directives has been widely reported in the literature (ADB 2005; Economy, 2003; Hills & Man, 1998; Jahiel, 1997; Lieberthal, 1997; Lo & Yip, 1999; Pei, 2006). Traditionally, a high level of scepticism greets bold Chinese pronouncements on new measures to reduce energy intensity, close down polluting factories or ramp up renewables. For example, the gap between rhetoric and reality in national energy policy epitomised this when the central government failed to meet the targets for reducing energy intensity as part of the Tenth and Eleventh FYPs (discussed earlier). Despite strong central government pronouncements on the need for energy efficiency, local governments continued to promote economic growth and allocated far more funds to energy production than to energy conservation (Andrews-Speed, 2004).

As long as a locality's main goal is to achieve economic growth, and cheap electric power is needed to fuel that growth, then environmental enforcement will play a secondary role. As one observer recently described the situation, local actors are now shaping China's energy markets at an unprecedented pace and scale, engaging in long-term investment decisions in fuel choice and technology that will remain in place for decades. Moreover, these actors are regulated by a fractured and diminished central bureaucracy (Cunningham, 2007, 2).

Driven by competition for higher economic growth, local jurisdictions are asserting their priorities, which do not always align with those of the central government. For instance, the competition for development is so fierce that local governments remain unwilling to cooperate with the central government or with their neighbouring jurisdictions for more efficient plants and are instead insisting on building small, less efficient and more polluting plants in their desire for self sufficiency and independent sources of tax revenue (China Intel Group, 2008).[51]

[51] For example, in 2008, the government announced measures to cease all new capacity in steel production and close small, inefficient steel mills through to 2011 by restricting bank credit. However, since the announcement a further 32 new capacity projects have been announced (Waldmeir, 2009). The Financial Times article cites a Steel

Similar examples of non-compliance abound in the case of energy policies. For example, since 2000, China's Law on the Prevention and Control of Atmospheric Pollution has been imposing national caps on total sulphur emissions, requiring coal-fired power plants to install pollution-reducing gas desulphurization systems, commonly known as 'scrubbers.' According to central government research, however, only about 10% of the coal-fired plants had purchased such equipment by 2005 (Lester & Steinfield 2006). Moreover, it was later found that many of the scrubbers were left switched off to save energy costs to the generators. More recently, the State Council reprimanded Provincial authorities for poor supervision of local lending practices: "Some regions act illegally, give approvals in violation of regulations or allow building before approval is granted" (cited in Lewis, 2009). Such open criticisms of Provincial authorities is uncommon and reflects Beijing's growing concern with provincial authorities deliberately ignoring the new energy efficiency standards and requirements with stimulus-related construction and infrastructure projects.

The example of the policy failure with the industrial consolidation program in the steel and iron industries highlights the resistance and autonomy of the local levels. Despite central government contracts requiring specific targets and evaluation procedures for the closure of 78 million tons of steel capacity and 89 million tons of iron capacity at the provincial level. According to Naughton (2009c), local governments avoided closure or consolidation by investing more in these sites, arguing that they were upgrading outdated plant and equipment with more advanced capacity (see Figure 37).

The growing support at the local level for the concept of a low carbon economy has resulted in an emerging shift in supporting the policies promoting energy efficiency. The key driver behind this change is the recognition that the clean technology and new energy sectors offer new economic opportunities for lifting local competitive advantage.

The introduction and adoption of new technologies will play a key role in minimizing GHG emissions (Socolow & Pacala, 2006). Currently, many promising technologies exist, but their adoption by industry has been slow. State policies can stimulate innovation and promote the adoption of technical developments, but they can also hinder these processes (Connor & Dovers, 2004; Lo Wing-Hung & Tang Shui-Yan, 2006). Recent research has focused on the efficacy of the state's implementation of environmental policies against the backdrop of China's ingrained institutional structure (English, 2006; Jahiel, 1997; SEI & UNDP, 2002). Moreover, there are increasing concerns of a growing disjuncture between central government policies and implementation at the local-level (Economy, 2003; Jahiel, 1997; Lo & Yip, 1999; Saich, 2001). Accordingly, "much of the environmental energy generated at the national level dissipates as it diffuses through the multilayered state structure, producing outcomes that have little concrete effect" (Lieberthal, 1997, 3). Some observers have linked these policy failures to the state's own complex institutional structure and management system (Lieberthal, 1997; World Bank, 2003). A key point emerging from this literature is the need to understand institutional constraints if policies intending to encourage the adoption of new technologies are to succeed.

Business Briefing, "'Beijing has shown it can't police these small mills … and many of the smaller companies are not even known to the government anyway,' says Graeme Train, China research manager for Steel Business Briefing. Mills often buy environmental equipment required by government – 'but then they don't use it', he says". See also Bloomberg (2009).

Given China's diversity, many local jurisdictions lack the capacity for appropriate policy development and implementation to support new technologies and innovation. Moreover, the criss-crossing jurisdictions responsible for energy efficiency programs can often slow down progress in implementation.[52] On the positive size, several cities have now declared themselves committed to the low carbon economy, such as Baoding, Shenzhen and Tianjin. Not only are these cities competing to attract clean tech and new energy firms, such as solar photovoltaic cell and wind turbine manufacturers, but they are also introducing energy efficiency targets and incentives for the adoption of cleaner production beyond those required at the national level. For example, in 2008 Beijing introduced the Civil Energy Act with the aim of promoting energy conservation, building energy efficiency and the use of renewable energy sources, such as solar and geothermal. The city government offers tariff reductions, tax incentives and penalties to support the implementation of the low carbon plan and to ensure that the city exceeds national targets and standards.

Local governments have played a critical role in facilitating the economic reforms and spurring economic development (Naughton, 2007). Furthermore, it is unlikely that there will be a noticeable shift away from this ideology of prioritising economic growth. In fact, it is likely that the economic imperative of bureaucratic decision-making will consolidate and strengthen during the next decade. However, the prevalence and pre-eminence devoted to this 'ideology of economic growth' within government decision-making and throughout society poses a number of serious challenges to non-economic policy areas, such as the environment, education, health and social welfare. While a narrow focus on short-term and immediate economic growth combined with the transformation of Chinese society and its landscape has brought about significant economic benefits, the pattern of development is deleterious to future growth and development (Saich, 2001, 295). Growing levels of social and economic inequality combined with environmental degradation are sowing the seeds of discontent, especially in rural areas. The central government is aware of these serious constraints; remaining highly sensitive to policy reforms to ensure that social, economic and political stability are not jeopardised.

Differentiated Development and the Implications for Energy Efficiency Policies in China

Given China's highly diverse and decentralised governance structure, it is clear that no energy efficiency policy can be successfully implemented without the cooperation of China's local governments, particularly provincial governments, which have responsibility for getting cooperation from county and city governments within their respective areas.

China's economy is made up of a large number of regions and is characterised by high levels of diversity in respect of income levels, economic structure, urbanisation, resource endowments etc. In the 1980s, regional diversity in income narrowed, but has been widening since the 1990s. The widening diversity of regional incomes has been a concern of the Chinese government for many years, and was the basis of Deng Xiaoping's aim to establish a "x*iaokang*" or (well-off) society by 2000. The launch of the western

[52] For example, Lin and Fridley (2007, vi) argue that achieving energy efficiency remains slow due to, for instance, the complicated regulatory "maze that governs the implementation of appliance standards". Similar problems delay the commercialisation of new technologies.

region development strategy in 2000, and the rejuvenation of the north-eastern industrial region in 2004 are specific initiatives in this direction.

These diversities are further compounded by the fact that since the SOE reforms of the 1980s, local governments have been given responsibility for services including health, education, science and technology and for the environment, without being given commensurate revenue sources to finance the provision of these services. At the same time, distribution of central government fiscal transfers, on which local governments heavily rely, are still weighted in favour of the wealthier provinces, even though this bias has been weakening gradually (see Grewal, 2008).

The lack of sufficient independent fiscal revenue has led many local governments into developing extra-budgetary sources in the form of 'illegal' taxes, fees and charges on local businesses. These taxes and charges are entirely arbitrary and undermine the enforcement of laws and regulations. Similarly, local governments have bypassed the legal prohibition on local borrowings by setting up bogus companies that serve as conduits for raising loans for local governments.

Regional diversities and constraints have shaped local perspectives and priorities that are often in conflict with those of the central government, and undermine the enforcement of economic and environmental policies. Local protectionism has become a major hindrance to policy implementation.

Specifically in relation to the implementation of energy efficiency policies, where local cooperation is crucial, a major issue to be resolved will be that different provinces face different trade-offs between rapid economic growth and energy efficiency, because of their respective industrial structure and developmental imperatives. The impact of a given movement towards greater energy efficiency on employment, incomes and welfare would also be different. In the past, the trade-off between economic growth and climate change has been considered to be an important factor in the indifference of China's local governments towards climate change mitigation policies until 2007 (see, Qi Ye et al., 2008).

The data in Figure 24, for example, show that in 2008, the ten most inefficient energy consumers in China were Yunnan, Liaoning, Hebei, Xinjiang, Gansu, Inner Mongolia, Shanxi, Guizhou, Qinghai and Ningxia. All of these are located in the inland regions of China and are also among the least developed parts of the country in respect of per capita GDP. These provinces are also generally more dependent on SOEs for employment and production, as private enterprises are not yet developed in these areas. These observations are consistent with those of Wei Chu et al. (2009) who find that the energy efficiency of China's regional economies is negatively associated with the secondary industry share in GDP, the state-owned economic share in GDP and the government expenditure share in GDP, and is positively associated with the technical level and the non-coal share in final energy consumption. The negative correlation of the share of state-owned sectors in the economy indicates that the greater the component of SOEs in the industrial sector, the lower the energy efficiency.

Hong Lijian (2004) went so far as to suggest that the opening up of the Western region remains a government campaign, run by government and for its benefit, and that private entrepreneurs, especially small and medium-sized domestic investors, would find it hard to participate in local economic reconstruction. He noted that "it would be very difficult to persuade profit-seeking domestic and foreign investors to put their money hereunder [sic] those circumstances". The high dependence on public sector employment in these regions also serves as a social safety net and makes downsizing inefficient enterprises more difficult.

Figure 24: Energy Efficiency and Marketisation in the Lagging Regions of China

Province	Per Capita GDP (RMB) 2007*	Marketisation Index**	Energy Consumption	Electricity Consumption	Energy consumption per unit of IVA
			Per unit of GDP		
National Average	18885	6.15	1.102	1357.29	2.189
Chongqing	14660	6.33	1.267	1090.19	2.106
Guangxi	12555	5.95	1.106	1254.15	2.335
Sichuan	12893	5.7	1.381	1156.37	2.477
Yunnan	10540	4.89	1.562	1654.94	2.847
Gansu	10346	4.86	2.013	2539	4.05
Inner Mongolia	25393	4.76	2.159	1887.32	4.19
Guizhou	6915	4.62	2.875	2452.21	4.323
Shaanxi	14607	4.15	1.281	1256.02	2.009
Ningxia	14349	4.02	3.686	5084.09	7.13
Qinghai	14257	3.4	2.935	4061.64	3.243
Xinjiang	16999	3.15	1.963	1331.24	2.999

Notes: Tibet is excluded as comparable figures for all categories are not available; IVA refers to industrial value added and is sourced from NBSC (2009).
Source: Compiled on the basis of figures from: * NBSC (2008, 2009); ** Refers to Population Weighted Score of Index of Marketisation figures for 2001, from Fan Gang et al. (2002).

The population weighted score of index of marketisation of China's provinces in Figure 24 is constructed by the Beijing-based National Economic Research Institute, and consists of the following 5 major areas that work as "main components" in the Index: Size of the government in the regional economy (I); Economic structure, mainly concerning the growth of the non-state sector and the reform of the state enterprises (II); Inter-regional trade barriers, including the price control (III); Factor-market development, including factor mobility (IV); and Legal frameworks (V).

The implementation of energy efficiency initiatives will affect the level and redistribution of income across China. Thus, as the use of coal is reduced progressively according to a low carbon policy from 71% of total energy production in 2005 to 27.2% in 2050, the coal producing provinces would suffer a disproportionately larger impact on incomes and employment. These losses may be counterbalanced, in some cases but not necessarily in all, by the development of alternative sources of energy, such as hydro, solar, wind, nuclear and biomass. The central government would need to subsidise heavily this process of weaning the economy off coal and petroleum as main sources of energy. The pace of this transition will set the limits of how quickly China can achieve its energy efficiency targets.

As noted elsewhere in the report, China still relies heavily on administrative or control mechanisms for policy implementation, including the career promotion criteria of senior personnel in central and local governments. These mechanisms continue to be utilised for promoting economic growth through investment and exports. Although these mechanisms have been reportedly adapted now to the requirements of energy efficiency targets, their success in delivering outcomes still remains to be tested (Xue Lan et al., 2006).

The deeper problem with such mechanisms of enforcement is that they are *ad hoc*, arbitrary, susceptible to be biased by corruption, and not based on merit. This means that enforcement of laws and regulations is not based on objective, predictable market-based criteria. As the OECD (2005) review of governance in China pointed out, the main emphasis of the enforcement mechanisms is on punishment for corruption and failure, rather than on avoiding the opportunities for corruption and the risks of failure.

Financial incentives of various types have also played an important role in policy implementation in China. In the context of climate change, the rapid adoption of the Clean Development Mechanism (CDM) by local governments in China is a good example. Several local governments in China have enthusiastically adopted CDM eligible projects and programs. It would help if the intergovernmental fiscal transfers are also based on objective and transparent criteria of fiscal need.

The post 1979 economic reforms have involved an enormous degree of experimentation, adaptation and flexibility between the role of the market and the old planning system. However, overwhelmingly the reforms have resulted in a gradually increasing role and presence of market forces in the economy. The fundamental state consideration is sustained economic growth whilst maintaining social and political stability. Therefore, the public signals are typically pro-market with exhortations to increase market openness, economic competition and the role of market signals. The deputy prime Minister, Li Keqiang, supported these moves recently at the World Economic Forum in January 2010 arguing that China would “allow the market to play a primary role in allocation of resources” (Bennhold, 2010).

China continues to experiment with an increasing reliance upon market mechanisms for the implementation of its energy policy. However, progress remains slow as ‘the institutions of government have, in most cases, failed to adapt their structure and function and many players in the economy remain aloof from the market’ (Andrews-Speed, 2004, 146). In an effort to combat this problem, the central government has recently attempted to introduce complementary administrative and market mechanisms. The combination of fiscal incentives promoting energy efficiency measures and new energy industries together with prioritised administrative directives since 2007 have been more successful in tackling earlier energy policy implementation problems.

Increasing Social and Regional Inequality

The current 11th FYP sets out an ambitious list of priorities aimed at tackling growing social and regional inequality in China. The key focus of current policies is strengthening social welfare. While important gains have been made in recent years in improving living standards, the divide between rural and urban areas has grown. In addition, the recent slowdown in export orientated industries has highlighted the employment pressures and vulnerability facing many of China's migrant workers. Current policies therefore include the introduction of a broad range of measures related to: access to free education, health coverage and pension support; the availability of urban and rural social security; improved labor standards; support for migrant workers; and, greater flexibility to the *hukou* registration. The *hukou* system refers to the household responsibility system, which has limited rural-urban migration and kept farmers on the land for the past half century. Reforms to this complicated system will be a core component of removing the divide between urban and rural residents and hence access to social welfare provisions. In 2010, *hukou* registrations will be relaxed in small and medium towns to facilitate ongoing urbanisation, but also to take some of the pressure of the larger cities.

Many of the ambitious government announcements of strategic social priorities, however, are not automatically translated into reality on the ground. China's current level of public spending on health care and education is quite low and resources are distributed very unequally among China's sub-national government jurisdictions – provinces, prefectures, counties and townships. According to the Asian Development Bank (ADB, 2005), public spending on education and health care declined as a proportion of GDP between 1994 and 2002 from 17.6% and 4.4% of total expenditure to 14.1% and 2.9% of total expenditure respectively. This is despite consistent calls from Beijing to increase the share of budgetary allocations to education and health. By 2008, expenditure had risen only slightly to 14.4% for education and 4.4% for health.

Responsibility for social services such as health and education rests primarily with sub-national governments, in particular at the county and township level of government. For example, in 2008 virtually all the budgetary expenditure for health (98.3%) and education (94.5%) was the responsibility of local governments. The overall shortage of public funding combined with unequal distribution of resources continues to result in serious issues of access and equity in vital areas of economic and social services, and to an increasing reliance on non-government funding. The widening income gap has exacerbated this problem with the Gini coefficient of inequality of household incomes widening from 0.16 in 1978, prior to the reforms to 0.47 in 2004 (World Bank, 2006). Between 2004 and 2009, the household income of the top 10% increased from 24.3% of total household income to 35.7%. A 2006 Report noted that just 1% of households control over 60% of the nation's wealth (Pei Minxin, 2006). Pei argues that government policies are exacerbating the widening disparity at the risk of social stability. The gap in incomes is typically a split between urban and rural as well as between coastal and hinterland households. The general over-supply of labour, especially in rural areas continues to depress low income labour and pose a challenge for the state in expanding employment.

In recent years, the Chinese government has been seeking to address these issues by not only directing more public spending into areas of greater need, but also by encouraging greater participation of the private sector in these areas and boosting wage protection. Whilst wage disparity is increasing, low income households (bottom 20% of households) experienced strong wage growth since 2007 when agricultural commodity prices rose, lifting incomes by 50% (Credit Suisse, 2010).

The growth in China's economic capacity has been stimulated by the huge productivity increases associated with increasing capital-intensity and strong growth in total factor productivity. These productivity improvements have been accompanied by rapid growth in the demand for goods and services associated with big increases in China's share of world exports and internal fiscal expansion. This has enabled the growth in employment opportunities to broadly match the increase in labour supply of between 1.0 and 1.5% per annum. However, China's employment growth rates need to be higher to maintain the increase in aggregate employment, especially as working conditions remain very basic for many rural migrants. Between 2000 and 2008, China achieved an average annual rate of 10.8% GDP growth while employment growth was only 0.9% or less than one tenth of output growth. According to Prasad (2009), this is one of the lowest rates of employment growth in Asia's developing economies. The main explanation for this disparity is that the negative employment growth in agriculture was balanced by 3% employment growth in the secondary and service sectors. The growth in the industrial sector was in fact largely attributable to labor productivity gains, less so with employment growth which only grew 1.6% annually, reflecting in retrenchment policies by state owned enterprises (SOEs). As a result, the growth in service employment is expected to meet the growing demand for employment, particularly at the local government level and provides a further justification for greater structural rebalancing.

The Environmental Cost of China's Development Path

There is a growing recognition that the natural environment is a major casualty of China's economic structure with accelerating levels of environmental degradation (Xiong Hongyang, 2005; Sheehan, 2008). Despite the government's vocal commitment to rebalancing the economy, critics point to the lack of progress in ameliorating China's environmental problems (Economy, 2007a; Li Yong & Oberheitmann, 2009; Pickles, 2002; Zhang Kunmin & Wen Zongguo, 2008). Domestic and international studies question the capacity of the state to produce tangible improvements in China's environment. They continue to note the uneven progress in tackling environmental degradation, emphasising that 'ecological destruction remains faster than remediation' (Xie Jun, 2000). And despite the concerted efforts of the state, they are failing to reduce the intensity and spread of degradation (SEI & UNDP, 2002).

China faces an array of serious environmental problems, including: increasing carcinogenic air particle matter in and around most large cities; dangerously high levels of organic pollutants in many of China's rivers and streams; severe water shortages; rapid desertification of China's grasslands; deforestation and soil erosion of upper valleys and catchments; widespread salinity; biodiversity loss; acid rain; increasingly frequent and more devastating natural disasters; and increasingly intense and frequent dust storms in northern China (Economy, 2004; Edmonds, 1994; Liu Jianguo & Diamond, 2005; Pan Yue and Zhou Jigang, 2006; Qu Geping & Li Woyen, 1984; World Bank, 2009b). While China's development remains at a relatively early stage, China's environment is witnessing a level of degradation so great that it may threaten the sustainability of China's economic growth and even the stability of its social system (SEPA, 2002; Economy, 2004; Liu Jianguo & Diamond, 2005; ADB, 2008). A World Bank report (1997, 2) estimated that the environmental cost of air and water pollution was equivalent to 8% of GDP in 1995.[53] The World Bank (2001, 85) indicated that many Chinese 'cities have [airborne] concentrations of fine particulates and sulphur dioxide that are amongst the world's highest'. A 2007 finding by the World

[53] The most conservative World Bank (1997) figures estimate the environmental costs of economic development of around 3.5% of GDP.

Health Organisation, World Bank and OECD found that air pollution had caused 750,000 premature deaths from respiratory disease in China (Coonan, 2007; Financial Times, 2007). While there is a broad range of serious environmental degradation of China's land, air and water due to the pattern of economic development, a key area of concern for this report relates to the role of energy, the resource intensity of production and the resultant carbon emissions. The low price of resources and the lack of a price for waste and pollution are blamed as key factors in the inefficient allocation of resources and high levels of environmental degradation occurring in China. And a consistent ingredient in many of these environmental problems is the nation's heavy dependence upon energy-intensive industry powered by coal.

These issues present a sobering reminder of the challenges confronting China's development path. The environmental challenges facing China are huge, and yet, the nation's mixed success in tackling them provides insight into the reach of the state and the ongoing divide between central government ameliorative policies on the one hand and unsustainable local government policies on the other. It is necessary that the central government quickly learn from the policy outcomes in the environmental realm in designing and implementing its structural rebalancing plans.

While many of the social welfare, health, educational and environmental reforms will be gradual in manner and take over a decade to be realised, there are certain aspects of the rebalancing program that need urgent attention and adjustments to ensure the delayed costs are not exponential in nature. This refers to sectors of the economy where the lock-in effects of poor decision making today will be felt for decades to come.

The Cost of Delay: The Risks of Lock-in Effects

There is an urgency linked to the problem of rebalancing China's economy due to the growing costs arising from the lock-in effect arising from everyday decisions by governments, companies and the public. This is especially critical in the three sectors of energy, transport and housing, which are rapidly expanding their energy use demands on the back of an increasingly urban population with rising living standards. Moreover, this problem is exacerbated by the limited time available for making cost-effective use of the technological opportunities available today and the potential implications of delayed action in terms of climate change. A recent report by McKinsey (2009) identifies many opportunities for energy efficiency, the application of technology and the diversification of fuel supply, but warns that while there is a 'window of opportunity' for greater efficiency gains, that window is a short one. And there is concern that the window is closing fast. This makes for a compelling argument for immediate action.

Therefore, time sensitivity remains a critical issue in making decisions regarding energy efficiency. To meet the expected growth in demand for the three key sectors of energy, housing and transport, China will further expand the construction of new power plants, highways, railways and buildings. Because such infrastructure will largely remain in place for the next 40-plus years, there is a need to ensure that such investments are carefully planned, executed and adopt best practice in terms of energy efficiency.

Previous sections have discussed the government's mixed record in tackling the lock-in effect within the power sector by closing down smaller inefficient power generators and those failing to meet pollution and energy efficiency requirements on the one hand, whilst failing to adequately regulate or monitor local government decisions on energy generation and use. Existing energy-related policies, especially related to consumption in the long-term will play a key role in shaping the structure and scale of final demand. In terms of the building sector, serious concerns remain with the current property boom across the country locking-in strong future growth in energy demand. Moreover, a major aspect of the rebalancing process involves calls for speeding up the urbanisation process and increasing domestic consumption as a driver for the economy. Both of these wield significant risks as well as opportunities for future energy use.

The Urban Billion and Rising Living Standards

There are several reasons for China's present rapid growth in energy consumption, but three reasons dominate: the strong presence of heavy industry in the economy, relatively low levels of per capita energy consumption and the rapid urbanisation of China's population. At around 1700 Kilowatts per person per year, China's consumption of electricity is only about one-fifth of the average per capita consumption in advanced countries. However, it is unlikely to stay at this low level for very long. There is a dependent relationship between future energy use, China's pattern of development, the rate of urbanisation and the lifestyle expectations of its people. While current levels of household consumption of electricity is not a critical factor in energy use, the growth in buildings, appliances and transport and attendant power demands are expected to become the major drivers of increasing energy use and carbon emissions in the near future.

Population growth and rapid urbanisation are a major driver of China's growing energy consumption. The share of urban population in China's total population has increased rapidly from 26% in 1990 to 45.5% in 2008 or from 254 million to 607 million people (see Figure 25). This is equivalent to an annual increase of almost 1% of the total population or about 13 million shifting to China's urban centres every year. During this period, one third of this increase or around 110 million people resulted from rural to urban migration. It is estimated that 1 billion Chinese will be living in urban areas by 2030.

Figure 25: China's Urban and Rural Population, 2005-2050

Population structure	2005	2010	2020	2030	2040	2050
Total population (million)	1307	1360	1440	1470	1470	1460
Urbanisation rate (%)	43	49	63	70	74	79
Urban population (million)	562	666	907	1029	1088	1138
Urban household size (persons)	2.96	2.88	2.80	2.75	2.70	2.65
Total urban households (million)	190	222	288	337	365	380
Rural population (million)	745	694	533	441	382	302
Rural household size (persons)	4.08	3.80	3.50	3.40	3.20	3.00
Rural households (million)	183	190	181	160	152	144

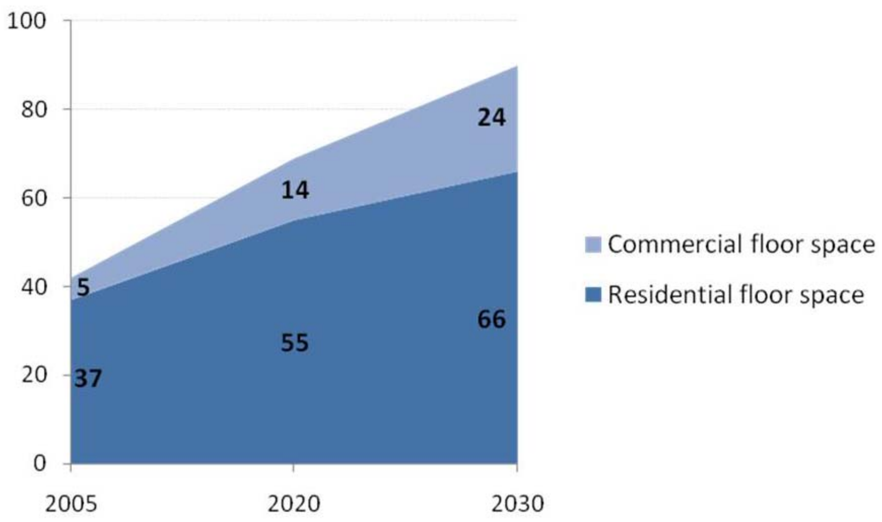
Source: CEACER, 2009

The urbanisation rate will remain steady over the next twenty years growing from the present 650 million or half of the population to 800 million in 2020 before reaching 1 billion by 2030 or two thirds of the total population of 1.5 billion. The growing urban population creates massive pressures on existing infrastructure as well as demands for the construction of new housing, offices and infrastructure, all of which require building materials, construction machinery, steel, cement, chemicals, power, land and water. Between now and 2030, according to McKinsey (2009, 32), 'China plans to build 50,000 new high-rise residential buildings and 170 new mass-transit systems' to cater for this new urban population. By 2030, China is expected to have around 337 million vehicles on the road and there will be 800 million air conditioner units.

Rising urbanisation has generated additional pressures on employment, consumption patterns and infrastructure construction, all of which in turn have contributed to higher energy demand. Residential energy consumption now contributes to over 11% of China's total energy consumption and is the second highest energy consumption sector following the industrial sector. Furthermore, there is already considerable scope for achieving energy savings by targeting urban households, whose energy consumption is three times that of rural households (Zhang Lixiao et al., 2009).

The combination of rapid urbanisation and rising living standards provides a serious challenge for China's economy beyond providing adequate housing, employment and social services, but to provide the necessary energy to power the cities of tomorrow. By 2030 there will be a further 350 million urban residents searching for employment and housing; all of whom will require new apartments, office buildings and commercial centres. Figure 26 highlights how commercial and residential floor space will increase by around 2 billion square metres annually or from 42m^2 billion to 91m^2 billion between 2005 and 2030.[54] As a result, the energy demands from buildings will double by 2030 (McKinsey, 2009; CEACER, 2009).

Figure 26: Estimated Growth in Building Floor Space, 2005-2030, billion m^2



Source: McKinsey, 2009

In 2006, regulations were introduced requiring the halving of energy consumption levels in new buildings compared to the current levels. However, very few existing buildings and not many new buildings, especially outside major cities such as Beijing and Shanghai, meet the new energy efficiency

[54] NBSC (2007) *China Statistics Yearbook* 建筑业房室建筑面 *zhi* [Construction area of building industry], National Bureau of Statistics China, Accessed June 2009 online http://www.stats.gov.cn/tjsj/ndsj/2007/html/01537.xls

guidelines. A green star building evaluation standard has been more successful in urban areas, especially in raising the levels of awareness of the importance of energy efficiency at the building design stage. The program has been less successful at the construction stage, but remains in its early days. Another buildings program has been the introduction of temperature controls for government buildings that requires winter heating does not exceed 20 degrees and summer cooling temperatures are set no lower than 26 degrees.

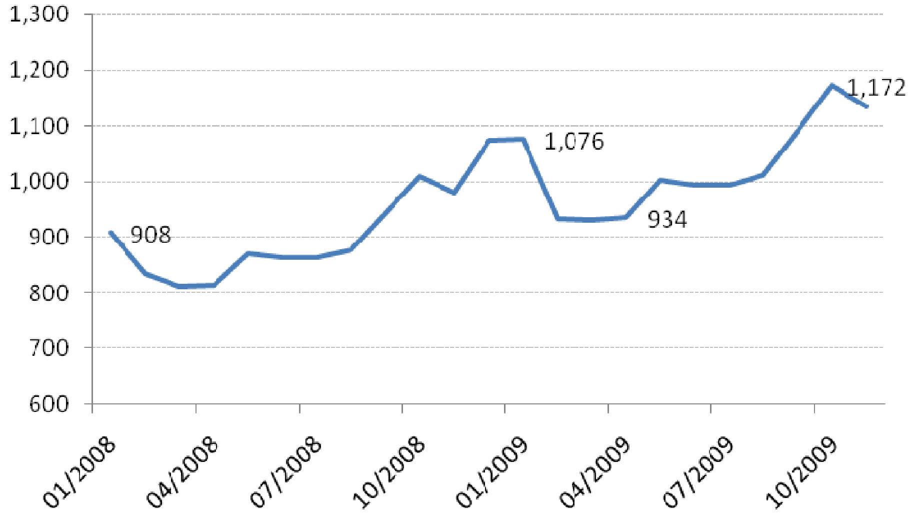
Conservative estimates of growing energy demand show the building and appliances sector's contribution to total energy consumption rising from the present 17% to 25% by 2030 which would require the construction of a further eighteen 1,000 MW coal-fired power stations. This increase would result in an annual increase of 80 million tons of GHG emissions so that by 2030 the sector produces 3.2 Gt of CO_{2}-e.

According to "China's comprehensive energy development strategy and policy" (State Council DRC, 2005) in order to reach a *xiao kang* society by 2020, energy efficiency programs should focus on promoting industrial energy conservation and energy efficiency in buildings and transport. The rising incomes, living standards and consumption patterns of these urban residents will fuel an appetite for larger residential and commercial buildings. By 2020, China's *xiao kang* society will entail a residential area of 35m^2 per capita, a population of 1.47 billion, an urbanisation rate of 55.78% and total residential area of 55m^2 billion. More critically, each household will most likely be equipped with all the indispensable list of requisite energy intensive functions and facilities, including air conditioners, PCs, plasma TVs, clothes dryer and the family car. The behavioural characteristics and lifestyle expectations of ordinary Chinese will play an increasingly important role in determining future energy demands and the success of energy efficiency initiatives.

The improving quality of life experienced by a growing number of Chinese is marked by increasing levels of consumption. While the main source of energy growth is energy-intensive heavy industry, consumption-led energy demand is set to become the main driver in the future. In fact, it is already playing a significant role in absolute terms. For example, despite the current global recession, Chinese consumers shifted into over-drive on the back of generous government subsidy, rebate and lending programs. During 2009, sales of consumer goods rose 15.5% or double GDP growth. For instance, vehicle sales in 2009 rose 42% compared with 2008 lifting China's vehicle market above the United States to become the largest with 13.6 million new cars and light trucks sold. Sales of household appliances, such as refrigerators, washing machines and other kitchen and laundry equipment, have experienced similar growth with total sales for 2009 expected to reach 185 million units (Bradsher, 2009).

In defiance of the literature arguing that the Chinese are conservative and discretionary consumers, an increasing proportion of sales are being funded by debt. In the first three quarters of 2009, household credit card use increased 40% and car loans rose 25%. By 2009, China had 175.2 million operating credit cards or seven times as many as in 2003 and 30% more than in 2008 (Financial Times, 2010).[55] There was a significant shift in lending in 2009 towards households when their share of lending increased from 15% in the first quarter to 60% by the third quarter (Naughton, 2009c). The resilient growth in retail sales data between July and October 2009 of 15.7% suggest that private consumption has rebounded from the impact of the global slowdown (Figure 27).

Figure 27: Retail Sales of Consumer Goods, billion RMB



Source: CEIC data, 2010

A combination of factors are behind the growing consumption levels in China, including rising household salaries, growing consumer confidence, greater access to credit and critically the recent government stimulus measures such as rebates and tax reductions. Interestingly, household savings rates have come down markedly in China from 26% in 2004 to 12% in 2009. Such a shift defies the accepted economic argument that savings will remain high until the current social reforms covering health, wages, education, social security and pensions, are fully implemented (Credit Suisse, 2010). During the same period, household income of the lowest 20% has risen by 50%, while the top 10% has grown 255% to around RMB34,000 per month. In comparison, the United States savings rate is around 4-6% and consumption levels five times higher than in China. Such levels correlate with GDP per capita figures and per capita annual incomes of US$2,775 in the city and US$840 in the countryside. However, as the Chinese rapidly scale up the wealth ladder, the gap in consumer spending between the two nations is expected to narrow. While offering a boon for retail outlets and manufacturers, the implications for energy and resource use as well as carbon emissions will become an increasingly challenging problem.

During the past three decades China's energy demand was largely driven by heavy industry and manufacturing, future demand, however, is expected to be consumption-led, particularly arising from the increasing use of household appliances, such as air conditioners and motor vehicles. Currently, this

[55] The same report cited credit card penetration rates of 0.13 per capita in China compared with 0.99 in the UK and 2.06 in the US.

sector is not a significant contributor to the energy use equation in China, but remains a critical consideration in decision making today due to the national and transboundary implications of 'getting it wrong'.

This section has outlined several important implementation considerations, including the governance limitations, the differentiated development experience and the risks of lock-in associated with current policy decisions. These issues offer a sobering reminder of the remaining challenges for more broadly rebalancing China's economy as well as achieving specific energy efficiency improvements. These problems will become harder for the government in Beijing to ignore, especially as the global and transboundary implications of China's developmental path increase. While rising standards of living, a growing urban population and sustained rapid GDP growth will increase China's GHG emissions, energy efficiency improvements, technological developments and embracing a more sustainable mode of development will bring down emissions significantly. The big question remains, however, by how much and how soon?

The Structural Implications of China's Energy Use for Emissions

If China's economy continues to maintain the current high levels of rapid growth, then over the next decade China is expected to double its GDP and to rank as an upper middle income country. Many of the policy and investment decisions made today wield ongoing implications for the future structure of the economy, China's pattern of energy generation and use, and carbon emissions. Therefore, China needs to accelerate existing policies promoting the quality of development rather than just quantitative expansion. While the rhetoric of the government has shifted dramatically to promote energy efficiency and economic rebalancing, fundamental structural economic inertia remains apparent and is likely to remain slow for another decade. This section discusses the more recent convergence of China's energy use policies with its climate change policies. An explanation for the government's position and chosen policy measures is provided before providing a detailed analysis of the relationship between carbon emissions and carbon intensity especially at the sectoral level. This is followed by a summary of the key findings and data of the recently released 'China to 2050: Energy and CO2 Emissions Report' (CEACER, 2009). This final section highlights some of the important structural considerations relating to the drivers behind the different growth scenarios for China's future energy use and carbon emissions.

The Convergence of Sustainable Energy Use and Climate Change Policy

In 2009, the Standing Committee of the 11th National NPC endorsed a draft resolution on new climate change legislation calling for specific plans and policies to develop a "green economy" and a low carbon economy, including increasing "green investment", and advocating "green consumption" and "green growth" (Li Jing, 2009). These policy measures shifted the focus on energy away from energy exploitation to energy conservation and improving energy efficiency and included a long-term energy-saving plan. In addition, they set the path for the introduction of specific sectoral and appliance energy efficiency standards. In terms of energy use, China is not only attempting to reduce overall energy use, but it is trying to gradually break its heavy dependence upon coal and introduce a more diversified and low carbon energy mix. The justifications for this shift include concerns over energy security, air pollution, climate change and economic competitiveness.

Between 1982 and 2007, the world emitted 715.2 trillion tons of industrial carbon dioxide into the atmosphere. Since 2000, global GHG emissions have grown by an annual average of 3.6% (Le Quere et al., 2009). Global emissions grew by a further 671 million tons between 2007 and 2008. Around half of the growth in global emissions during the past decade can be attributed to China, especially the rapid expansion of its energy-intensive industrial sector. Therefore, action by China in rebalancing development, curtailing the growth of energy use, and in effect carbon emissions, is critical both at a domestic level and at a global level. Unlike most other industrial economies, China has spent very little time debating the evidence behind climate change, but instead accepted the scientific consensus and responded with a raft of policy measures.[56] China's efforts to adopt a more sustainable use of energy are intimately linked into the nation's climate change and carbon emission policies. Beijing recently introduced a synthesised national-level Climate Change Program (NDRC, 2007).[57] The program was launched with the aim of building a resource efficient and environmentally friendly society, enhancing national climate change mitigation and adaptation and contributing to furthering global climate protection.

Energy efficiency is acknowledged as offering the lowest cost and most effective method of achieving energy conservation whilst reducing GHG emissions (see Figure 36). Energy efficiency can potentially provide over half the energy-related emission abatement potential within the next 20 to 40 years (IEA, 2006; IPCC, 2007c; McKinsey, 2009; Per-Anders et al., 2007; Stern, 2007; World Bank, 2007). As mentioned, China's top priorities in the 11th FYP (2006-2010) include sharply reducing energy consumption per unit of output and making energy production and use less damaging to the environment, while maintaining rapid development. It is estimated that if China can realise the 20% reduction in energy intensity during the Plan, then it will reduce carbon emissions by over 1 billion tonnes annually or four times the EU-15's commitments under the Kyoto Protocol (Chatham House & E3G, 2008). McKinsey (2009, 9) conclude that China can achieve energy intensity per unit of GDP reductions of almost 20% every five years for the next 20 years. Moreover, much of the mitigation potential for reducing carbon emissions can be effectively achieved through low cost and existing technological improvements.[58] The benefits of these energy efficiency gains will result in the abatement of GHGs from business as usual of around 7 billion tons of CO_2e. This is well in excess of the combined GHG emission commitments made by the EU, Japan and the US during the COP15 meeting in Copenhagen. In a further strengthening of energy policy, China announced the extension of its energy

[56] There has been some debate on climate change, especially around the issue of responsibility. For instance, after the 'collapse' of the Copenhagen climate negotiations, one of China's leading climate negotiators and NDRC vice-chairman, Xie Zhenhua, argued that "uncertainties" remain over the cause of global warming, and therefore an "open attitude" towards different understandings are necessary (Kazmin, 2010). According to Xie, climate change is a "solid fact" and the main cause is "the unconstrained emissions of developed countries during the industrialisation process …, but there are some uncertainties".

[57] The full-text of the National Climate Change Program is available: http://www.china.org.cn/english/environment/213624.htm

[58] According to the China Environmental Service Industry Association, energy efficiency projects can provide up to a 200% return on investments with an average of around 30%.

efficiency targets in 2009 into a carbon intensity target. These decisions reflect the gradual convergence of climate policy and energy policy in China during the past five years. It is hoped that this plays an important role in ensuring a higher level of compliance and implementation of policies at the sub-national level.

China's Climate Change Program acts as a guiding document for more specific policies and approaches to climate change both domestically and internationally, including China's existing GHG emissions, the impact and challenges of climate change on China, various policy measures for tackling climate change and China's guiding position, principles and objectives on commitments to climate change. At the same time, the State Council established the National Leading Group on Climate Change Strategy (NLGCCS) led by the premier.[59] The NLGCCS consists of 27 agencies and is responsible for making decisions and coordinating national actions on climate change. Equivalent groups have been immediately established at the provincial, prefectural, municipal and county levels[60] to:

> *Organize implementation of the national strategies and policy on climate change; to design provinces' actions on climate change, energy saving, and pollution reduction; to review plans on international collaboration and strategies on negotiation; and finally to coordinate key provincial actions on climate change, energy saving, and pollution reduction.* (Qi Ye et al., 2008, 295)

As a result of these initiatives, a hierarchy of leading groups on climate change and/or energy saving and pollution reduction has emerged for the formation, implementation and coordination of energy policy in China. The speedy formation of these agencies at all levels of government signals the priority afforded to this issue (Qi Ye et al. 2008).

In 2008, the government published its *Climate Change White Paper* (2008). China's position on climate change is clearly set out in the *Five-Year Plan*, the NLGCCS, the *Climate Change Program* and the *White Paper*. These policies focus on achieving national energy efficiency gains through a broad range of policy measures. A consistent theme within China's climate change strategy focuses on the role of cleaner production and energy efficiency for mitigating emissions.

In 2009, Premier Wen Jiabao announced that climate change considerations would be incorporated into the medium- and long-term development strategies and plans of every level of the Chinese government. The accompanying State Council announcement also called for increasing investment in low carbon industries as well as the construction and transport sectors. At the same time the National People's

[59] The NLGCCS replaced the National Coordination Group on Climate Change (NCGCC), which was headed by a Vice Premier and had been established by the State Council in October 2003. The NLGCCS works along with another companion body namely the National Leading Group on Energy Saving and Pollution Reduction (NLGESPR). The composition of NLGESPR is basically the same, as both groups are lead by the Premier and consist of the same agencies: 'They are one group of agencies and officials but work under two different titles' (Qi Ye et al., 2008). Because of their different goals and objectives, the secretariats of the two groups are located in different agencies.
[60] Naughton (2009b) describes a similar rapid administrative response to the global financial crisis in late 2008 when the hierarchical structure of the communist party was utilised to rapidly marshal the lower level governments into action.

Congress passed a resolution on climate change with the aim of restructuring the existing carbon intensive development model whilst still promoting growth by maximising efficiency, lowering energy consumption and minimising carbon emissions.[61]

In September 2009, President Hu Jintao announced that China would convert its energy efficiency targets into reductions of carbon emissions per unit of GDP. Such an approach tackles the dual goal of reducing both energy and carbon intensity. More importantly, this switch to reporting CO_2 emissions will align China with developed economies on providing measurable, reportable and verifiable (MRV) emissions (WRI, 2009).

> *In the years ahead, China will further integrate actions on climate change into its economic and social development plan and take the following measures: First, we will intensify effort to conserve energy and improve energy efficiency. We will endeavor to cut carbon dioxide emissions per unit of GDP by a notable margin by 2020 from the 2005 level. Second, we will vigorously develop renewable energy and nuclear energy. We will endeavor to increase the share of non-fossil fuels in primary energy consumption to around 15% by 2020. Third, we will energetically increase forest carbon sink. We will endeavor to increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from the 2005 levels. Fourth, we will step up effort to develop green economy, low carbon economy and circular economy, and enhance research, development and dissemination of climate-friendly technologies.*
>
> *President Hu Jintao at the UN Climate Change Summit*

To fully appreciate these comments by President Hu, it is necessary to briefly articulate the political context behind China's position and response to climate change. In so doing, it becomes more apparent how China plans to implement a low carbon economy through divergent yet parallel strategies.

China's official position on climate change rests firmly within the United Nations Framework Convention on Climate Change (1992) and the Kyoto Protocol (1997) which state that action on climate change should be in accordance with each nation's "common but differentiated responsibilities and respective capabilities and their social and economic conditions". Moreover, developed economies "should take the lead in combating climate change and the adverse effects thereof". China's position that the mitigation of carbon emissions is the responsibility of the developed world is predicated on several arguments.

Firstly, the developed world wields a sizeable historical debt with significant emissions since the industrial revolution. For example, between 1805 and 2005, the US and UK have each produced 15 times the amount of GHG emissions compared with China (see Figure 28). Even if examined from a more recent historical perspective, China's cumulative contribution to CO_2 emissions from 1900 to 2005 is 8% of total global emissions or less than one-tenth that of the United States, which contributed around 30% of emissions (IEA, 2009a).

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[61] Xinhua (2009) China's Legislature Endorses Climate Change Resolution, *Xinhua*, 27 August online: http://www.chinadaily.com.cn/china/2009-08/27/content_8625536.htm

Figure 28: Accumulated Carbon Emissions, 1805-2005, gigatons of CO_2-e

UK	1121
US	1110
Germany	959
EU27	762
France	528
Japan	335
Korea	190
China	71
China (2030)*	194

Note: * Estimate
Source: CEACER, 2009

Even if the period 1960 to 2005 was examined, China's total emissions are only one tenth of those produced from the US.

Secondly, while China is now the largest source of GHG, much of these emissions are generated by manufacturing industries that shifted production to China from the West and have helped developed economies reduce their own emissions. Moreover, these factories and industries are producing goods for export to feed the demand for consumer items and materials in the West (Weber et al. 2008). According to research by Davis and Caldeira (2010), China is the largest exporter of emissions, mostly to the US, Europe and Japan. If trade embedded emissions were included in the global GHG calculations, then the US would remain the largest emitter and China's emissions would be reduced by 20%. As such, China argues that the West needs to share some responsibility for such emissions.

Figure 29: Global GHG emissions, 2007

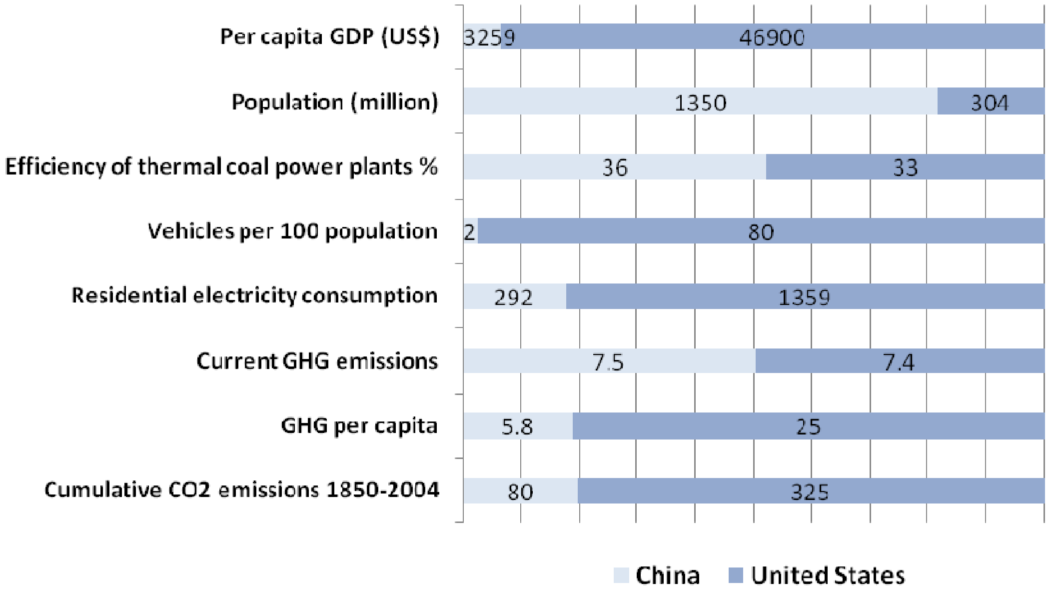
	GHG emissions (Gigatons CO_2-e)	Annual growth rate (1990-2007)	Total per-capita emissions (tons per capita CO_2-e)	GHG intensity of domestic production (2005) Tons CO_2-e per US$1000 GDP
China	7.6	4.7	5.2	3.6
United States	7.2	1	24.3	0.7
Indonesia	3.5	12.7	14.1	12.8
Brazil	2.6	3.1	13	
Russia	2.1	-2.4	14.6	
India	2.1	3.6	1.5	3.7
Japan	1.3	1.3	12	0.4
Germany	0.9	-1.3	12	0.5
Canada	0.8	1.9	24.9	0.8

Source: IEA, 2009; WRI,2009; McKinsey, 2009

Thirdly, on a per capita basis China's emissions are 5.2 tons of CO_2 per capita or around one fifth of America's 24.3 tons or Australia's 28.7 tons per capita (McKinsey, 2009).[62]

[62] Based upon 2005 figures.

Figure 30: Comparison of Chinese and US Energy Statistics



Source: Seligsohn et al., 2009

While Figure 29 shows China as the world's largest anthropogenic CO_2 emitter and the US the second largest, producing more emissions than the combined total of the next four largest emitters: India, Russia, Japan and Germany. While China and the United States' are the largest global emitters, the discrepancy in each nation's emissions is more obvious from a per capita or historical perspective. For example in 2008, despite US emissions declining by almost 192 million tons or around 3% following the global financial crisis, the US remains the main GHG emitter amongst the large economies producing almost 25 tons of carbon dioxide per capita compared to the world average of 5.3 tons. A more detailed comparison of energy statistics between China and the United States is instructive (Figure 30), especially given the high level of tension in negotiations during and following the 2009 Copenhagen meeting and the apparent gap in understanding. China's per capita emissions remain well below the United States as highlighted by the disparity in residential energy consumption, which reflects the developmental gap between the two nations.

Fourthly, as China still remains a developing economy it argues that it should not have to limit its level of development due to something beyond its responsibility. China remains a low to middle developing economy with a per capita GDP of around US$3259 in 2008, which according to the IMF (2009) ranks it 104th among 180 countries and regions. Moreover, it argues that its share of emissions will continue to grow to meet the social and economic needs of its people. Therefore, any actions it takes will be dependent upon progress in tackling poverty as well as efforts to raise the level of the populace's development.

Finally, in terms of preconditions for action on climate change, China returns to the 1992 UNFCCC and 1997 Kyoto Protocol which both clearly articulate the responsibility of the developed economies to: lead on cutting emissions; and provide financial assistance as well as share energy efficient and carbon reduction technologies with developing economies.

It is clear that China remains sensitive to being seen as framing carbon emission commitments within its clearly articulated position that the developed world should lead and as a low to middle income developing economy its growing carbon emissions do not need to be curtailed until it has attained a reasonable level of wealth. Moreover, it hopes that through the process of developing a global agreement on climate change, China will receive both technical and financial assistance from the West. Ironically, despite all the conservative pronouncements at the global level during the past decade, China has already dramatically shifted its stance on the domestic front due to a growing acknowledgement that unrestrained carbon emissions, environmental pollution and inefficient resource utilisation will not lead to prosperous development. Instead, China's structural rebalancing program has received a further boost following the realisation that the challenges of climate change can provide additional economic development opportunities by embracing a low carbon economy. China recognises that improving energy efficiency and reducing carbon emissions is not only critical to its national security but provides an enormous opportunity for future economic prosperity.

Carbon Emissions and Carbon Intensity

Due to the combination of the global economic slowdown and positive government steps in tackling energy efficiency in China, by the end of 2008 China's CO_2-e emissions slowed to an annual increase of 6%, which is the lowest annual increase since 2001. The slowdown in China's emissions growth contrasts with a trend since 2004, when its emissions increased by 17% largely due to the aforementioned rapid growth in heavy industry.

Figure 31: Carbon Efficiency and GDP Growth Comparison, 2007

	GDP carbon efficiency improvement	GDP growth rate
China	4.9	10.1
India	1.3	6
Indonesia	4.4	-1.4
Australia	3.5	1.3
Saudi Arabia	3.1	-2.5
United States	3	1.7
France	1.9	1.5
Germany	2.7	1.6
Japan	0.3	1.3
Russia	2	-0.7

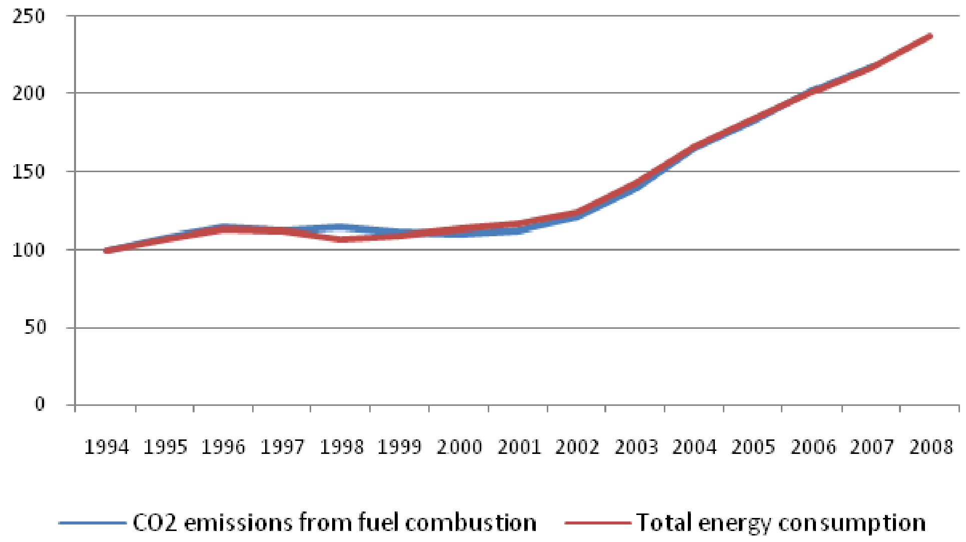
Source: McKinsey, 2009

During the past 20 years, China has achieved significant improvements in reducing its carbon intensity as a unit of GDP. According to McKinsey (2009, 35), China had the highest carbon efficiency improvement rate in the world between 1990 and 2005. While annual growth averaged 10% during this period China's carbon intensity per unit of GDP reduced by 4.9%. In other words, for every increasing 10% of GDP growth, China has been able to reduce its carbon footprint by nearly 5% (see Figure 31).

As mentioned, President Hu announced that China would extend the national energy intensity targets into a carbon intensity figure. This significant cut was later announced as a 40-45% reduction in carbon intensity by 2020 based upon a 2005 base year.[63] It is expected that China will incorporate a carbon efficiency target in the 12th and the 13th FYP between 2010 and 2020, which will be backed up by legislation and targeted policy and implementation programs. The carbon intensity targets correlate with the energy efficiency targets as well the timeframe matching China's increasing renewable energy commitments and expectations for a peak and decline of its carbon emissions by 2030 (see Figure 35).

According to CSES analysis, China's carbon intensity is set to decline by 42.5% on a BAU scenario in 2020 relative to 2006, with annual emissions growing by 4.3% over 2006-30 and annual GDP growth of 8.1%. State media also reported that China's CO_2 emissions per unit of GDP had reportedly decreased between 2007 and 2008 by 10%.[64] Therefore, the carbon intensity reduction announcement was greeted with a certain level of cynicism by those expecting a reduction of at least 50% or more.[65]

Figure 32: CO_2 Emissions from Fuel Consumption and Total Energy Consumption, China, 1994-2008 (indexes 1994=100)



Source: IEA database (for details see Appendix)

However, it should be appreciated that for China to hold itself to the BAU scenario, significant challenges remain. First and foremost, energy use and energy intensity figures have once again diverged from national policies due to the 2008-2010 economic stimulus package. Moreover, the BAU scenario is

[63] According to Professor He (Director of Tsinghua University's Low Carbon Energy Laboratory), China is currently developing its national GHG emissions inventory for the UNFCCC Second National Communications with some international assistance (cited in Seligsohn, 2009)

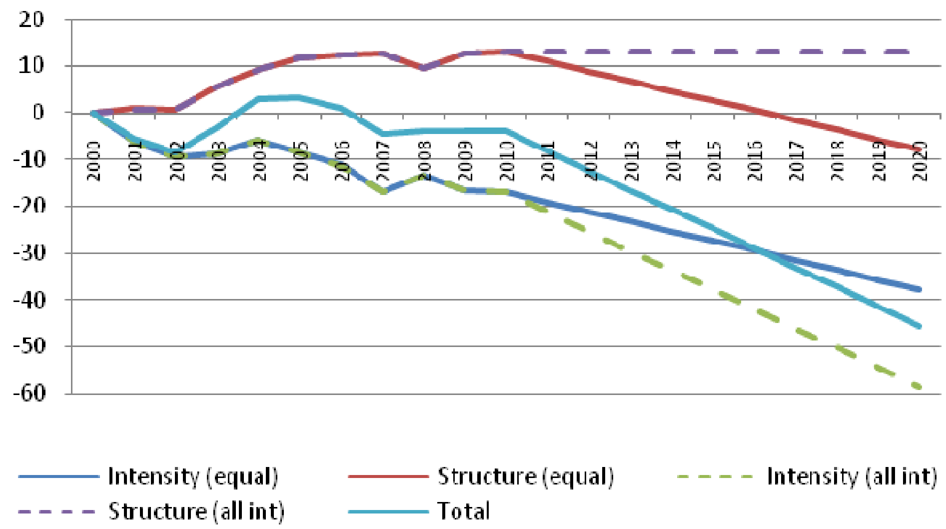
[64] China Daily, 23 September 2009 http://www.chinadaily.com.cn/bizchina/2009-09/23/content_8724671.htm

[65] China's commitments to reducing its energy intensity are often met with scepticism, yet it is rarely acknowledged that their efforts will reduce global GHG emissions by a more significant amount than the combined reductions promised by the wealthy developing nations of Europe, Japan and the United States. Implementation will however remain the key indicator.

largely based upon new policies introduced since 2007, such as the intensification of the policy measures for achieving the energy efficiency targets and new support for renewables and low carbon energy. However, it is still unclear how successful these policies will be or what implementation resistance they will encounter at the local level. Finally, emissions per unit of energy use change only slowly (Figure 32), as this requires changes in the energy supply mix and an increase in the emissions efficiency of energy production (for example, by the introduction of carbon capture and sequestration). Thus we take it that China's Copenhagen commitment implies a reduction in emissions intensity of at least 40% by 2020, relative to 2005. On our estimates this implies a reduction of about 36% on 2010 levels.

As the previous discussion implies, such a reduction can be achieved by either reducing the energy efficiency of individual industries or by shifting the structure of GDP to a less energy intensive one, or both. In Figure 33 we explore two alternative paths: one in which the adjustment is equally shared between the intensity and structure effects, and the other in which industry structure is held fixed and the reduction is achieved by reducing the energy intensity of industries within that structure.

Figure 33: Achieving a 40% Reduction in China's Energy Use Per Unit of GDP by 2020: Intensity and Structural Contributions on Two Separate Paths, 2000-2020, thousand tons of SCE per billion RMB at 2005 values



Source: China National Statistical Bureau; CEIC database and estimates of the authors (for details see Appendix)

These estimates indicate that, if the composition of China's GDP remains fixed at 2009 levels, very rapid adjustment in industry-specific intensities is required to achieve the 40% reduction target, and that the pace of reduction needs to accelerate markedly from that achieved over 2000-09. On the other hand, if the burden of energy reduction is shared equally between structural and intensity factors, achieving the 40% reduction target is consistent with a continued fall in energy intensities in line with 2002-09 trends. The balance between these two factors is ultimately a policy choice, but it is evident that changes to the structure of GDP can make an important contribution. China's policy stance in the 11th Five Year Plan period has been to pursue action on both fronts: to reduce energy emissions by aggressive action to reduce energy intensities within industries but also to attempt to change the structure of GDP.

The energy efficiency and carbon intensity targets will remain challenging for China to maintain (particularly beyond 2020), especially considering the re-intensification of energy intensive industrial production following the government's stimulus package and existing policy commitments.

Attaining an Emissions Peak and Decline Scenario

Notwithstanding the global financial crisis and the constraints of climate change, the outlook for China's energy demand is for continuing high rates of growth for many years to come. It is estimated that if current patterns of economic growth and energy consumption continue, China's total annual primary energy demand would increase from 1297 million tons of coal equivalent (Mtce) in 2000 to 3280 Mtce by 2020. While coal consumption is expected to increase by 3% per annum between 2005 and 2030, the share of coal in China's energy mix would decline from 69.9% in 2000 to 63.2% by 2020, and its CO_2 emission would reach 1940 Mtce by 2020 (IEA, 2009a).[66] Acknowledging the growing levels of development in China, strong growth in demand for energy and rapidly rising carbon emissions are critical domestic and international issues.

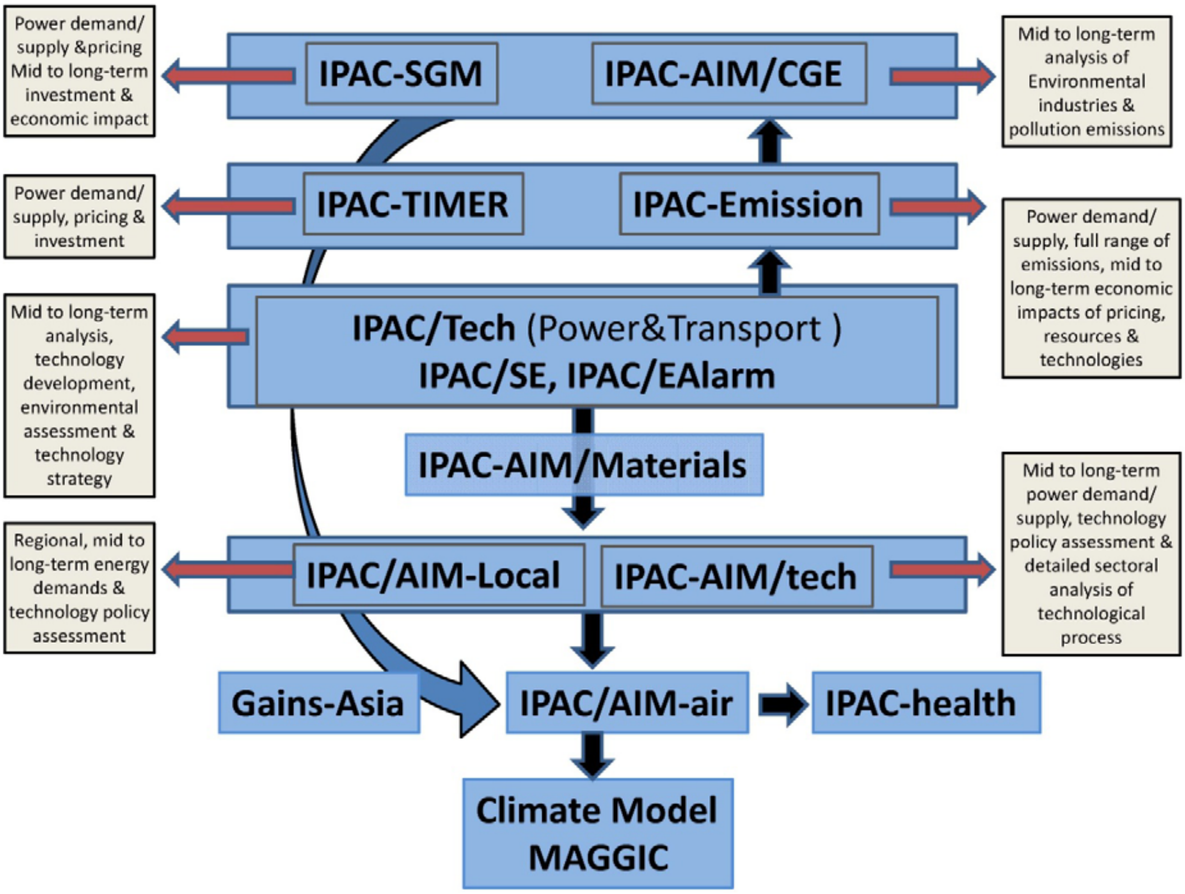
The gravity and complexity of fully understanding the drivers and implications of such changes in China have been a strong focus of the central government for over a decade. One of the key outputs of China's effort in this area has been the formulation of the IPAC-AIM modelling framework (China Energy Environment Integrated Assessment Model; 中国能源环境综合评价模型 IPAC 框架).

This framework is one part of a complicated quantitative model utilising global IPCC (2007a) methods for incorporating economic, social and technological aspects at the local and provincial levels to determine a variety of emission pathways and energy use scenarios for China. The model provides useful background into China's complex economic situation as well as incorporating global economic factors, such as trade. The framework has been gradually developed by ERI together with literally hundreds of domestic and international research collaborators over the past 15 years. This section of the report includes some of the scenarios and modelling results for projected economic activity and carbon emissions through to 2050 emanating from the 2009 report titled '*China to 2050: Energy and* CO_2 *Emissions Report*. The report is a joint publication by members of the China Energy and CO_2 Emissions Report Group (CEACER, 2009), which includes the Energy Research Institute of the National Development and Reform Commission, the State Council Development Research Centre's Industrial Economics Research Department and Tsinghua University's Institute of Nuclear and New Energy Technology.[67]

[66] The IEA reduced its estimates of annual coal demand in China from 3.2% to 3% following the policy success I closing down small, inefficient coal-fired power plants and replacing them with more efficient supercritical coal plants.

[67] The report is published in Chinese, titled: 2050 中国能源和碳排放报告, Beijing, Science Press, but it is expected that most chapters will be available in English shortly following their publication in international journals.

Figure 34: Integrated Policy Assessment Model used by CEACER



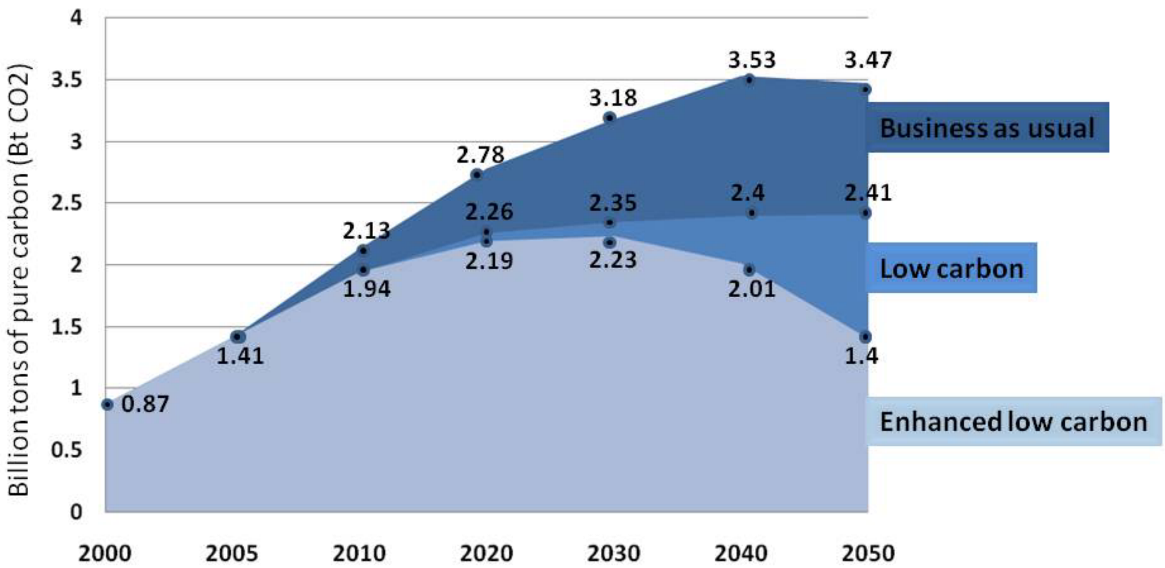
Source: CEACER, 2009

Figure 34 provides details of the modelling for the CEACER report, which incorporates several components. Firstly, the IPCC's IPAC-emissions model was adopted, including global energy demand and supply, GHG emissions, targets and burden sharing relationships, energy imports and exports, energy prices and reduction costs. Secondly, an energy and computational general equilibrium economic model (IPAC-CGE) was used covering major industries and sectors including future economic sector details, energy intensive industries and a reduction cost. Thirdly, an energy technology model was incorporated following the IPAC-AIM approach to analysing the impact of a range of different technologies (up to 600) and includes China's energy and emissions scenarios, energy demand by sectors, energy supply and reduction costs.

Several key considerations are included in the model, including: the issue of burden sharing (equity); structure of the economy, especially the role and impact of manufacturing; and, identifying broad government policy perspectives and measures required to bring about emission reductions of 50% by 2050. A key focus of ERI's research for the report has included examining a peak and decline approach for China's GHG emissions and "back-casting" the necessary reductions in the various sectors based upon technological and behavioural estimates.

The ERI IPAC-AIM model includes 6 scenarios, however due to the media's emphasis on only three scenarios, ERI have generally limited themselves to just three scenarios in public discussions including: the baseline (BAU), a low carbon policy (LC) and an enhanced low carbon scenario (ELC) (see Figure 35). In terms of CO_2 emissions, the focus is on a peak and decline approach with a 2030 peak of 2.23 Btce following the ELC scenario, whereas emissions continue to grow until 2040 to around 3.53 Btce under BAU. The ELC scenario then suggests a steady decline in emissions returning to 2010 levels by 2035 and 2002 levels by 2050. Following a low carbon policy approach, CO_2-e emissions stabilise by 2030, but fail to achieve a decline by 2050 when emissions continue to grow; reaching 2.41 Btce. The key finding in the report is that China's emissions could begin to slow from 2020 with a peak around 2030. Such a scenario is even more ambitious than the commitments from most developed economies and would therefore be favourably viewed in international negotiations.

Figure 35: ERI IPAC-AIM Model of CO_2 Emission Scenarios



Source: CEACER, 2009

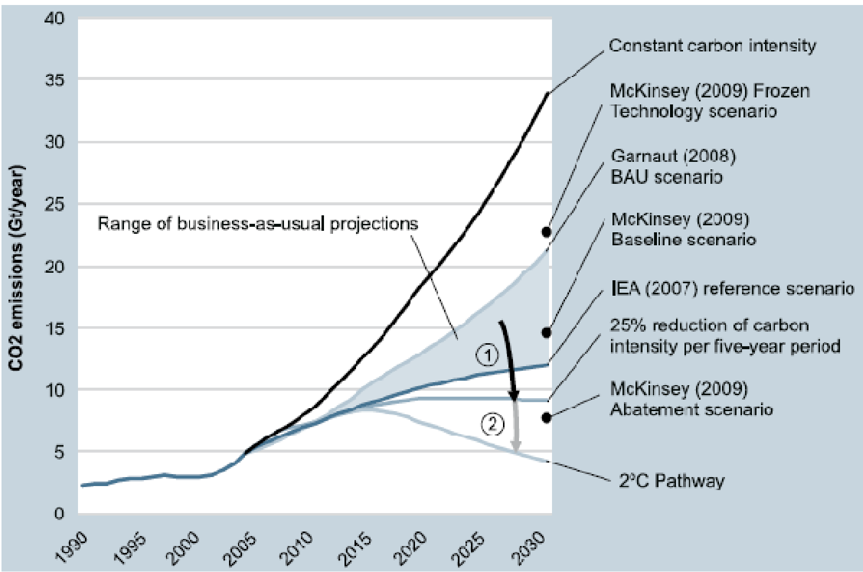
The key outcomes of the ERI modelling for embracing a low carbon approach compared to business as usual by 2050 is a reduction in primary energy demand and CO_2 emissions of 26.8% and 44% respectively. This will require an optimisation of the nation's energy structure away from coal (declining from 44% to 37.4%) and oil (declining from 27.6% to 20.2%) and towards nuclear (increasing from 9% to 14.2%) and renewables (increasing from 9.4% to 13.8%) as well as a reduction in overall energy demand. According to ERI, additional assumptions arising from the scenarios in Figure 35 include: per capita income is expected to increase ten-fold from RMB20,000 in 2010 to RMB200,000 by 2050; and China's CO_2 emissions will reach 5.5 billion tons in 2010 with a peak scenario in 2035 of 8.8 billion tons. In summary, the key conclusions of the ERI study found that:

- the most significant gains in energy efficiency will come from the industry and transportation sectors;

- China's per capita GHG emissions will rise from 3.58 tons in 2004) to 4 tons in 2010 and 6 tons in 2050, which is equivalent to a 50% increase from 2010 to 2050;
- CO_2 reductions remain dependent upon the application and widespread penetration of existing and new low carbon technologies;
- the costs are not much higher for a low carbon approach, but the opportunities and benefits are significant especially in the global context; and
- timing is critical and there remains an urgent need for the State Council to adopt climate and energy planning, including carbon emission targets, within the Five Year Plans (FYP), including the forthcoming 12th FYP or at least the 13th FYP at the latest.
- Challenges remain, especially for managing the growing demand for oil and gas as well as adopting carbon capture and storage (CCS) by 2030.

The Stockholm Environment Institute (SEI, 2009) provides a useful comparison (Figure 36) of different emission pathways based upon a variety of recent analyses of possible abatement scenarios (Garnaut, et al., 2008; IEA, 2007; CEACER, 2009; McKinsey, 2009- see SEI, 2009). SEI divides the pathways into three groupings. Firstly, the higher emission scenarios based upon business as usual with little or no technological improvement and retention of existing energy intensity figures. Secondly, a status quo low carbon policy approach achieving 25% improvement in carbon intensity every five years through to 2030. Thirdly, the enhanced low carbon scenario based upon 'backcasting' to keep global temperature increases to below 2 degrees Celsius. The different scenarios highlight the enormous gap between BAU and low carbon policy scenario (arrow 1) and the enhanced low carbon scenario (arrow 2). It is important, however, to keep in mind the difficulty in terms of the accuracy of these models, which make enormous assumptions in terms of parameters and weighting. Therefore, caution and careful considerations is necessary as Figure 37 highlights in relationship to the problems with estimating the contribution of the steel industry.

Figure 36: Schematic Overview of Possible Future Emission Pathways for China



Source: SEI, 2009, 5

Prior to discussing the key drivers for China's projected increase in emissions, the basic economic and population characteristics for China going forward to 2050 are introduced. Understanding the underlying trends of population growth, future industrialisation, economic development and urbanisation are essential in appreciating both the opportunities and constraints for achieving more sustainable energy use and realising a low carbon economy.

Figure 37: Note on CEACER Model and Scenarios

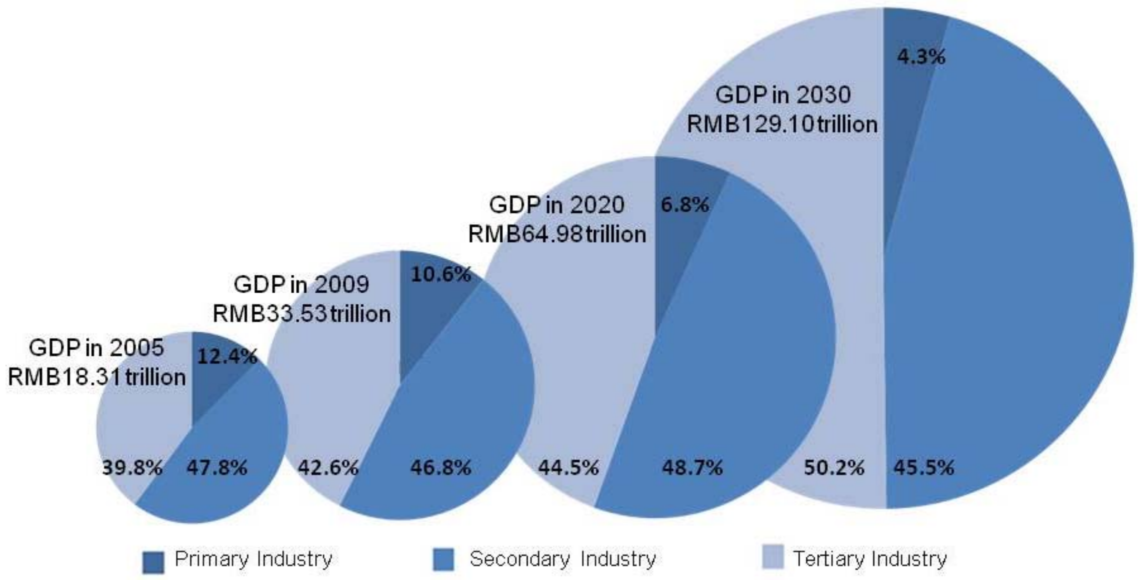
The assumptions and projections in the CEACER report (2009) scenarios have been challenged somewhat due to the rapid economic growth of the past few years and the rising steel and energy figures. The strong growth experienced between 2005 and into 2008 requires some of the baseline data to be reviewed.[#] This is especially important following the central government's stimulus program which resulted in a massive economic rebound, especially in the energy intensive heavy industries. For example, steel production rose significantly in China during 2009 by 14% compared with 2008, despite the global economic slowdown that resulted in the global production of steel declining by around 25% in countries other than China. According to the CEACER BAU scenario, steel output doubles between 2005 and 2020 from 355 to 710 million tons respectively. China publicly claims to already have the capacity to produce 700 million tons of steel.[##] By the end of 2008 steel output reached 530 million tons, rising to 568 million tons in 2009, equivalent to half the world's steel. Based upon recent growth figures, China's steel production could reach over 3500 million tons by 2020 or 400% over the CEACER BAU estimates. Such discrepancies in baseline figures and growth forecasts questions the reliability of projections for 2020, especially assuming that under the projections growth in steel output flattens out post 2020. And yet, all signs show that steel will in fact continue to grow to meet strong demand, especially in the infrastructure and housing sectors. Following discussions between CSES and ERI, ERI argued that this growth in steel production was considered unsustainable in the medium to long term and is expected to eventually slow down after 2010. The initial 2010 projections are now being left out of publications due to recent central government policy measures and industry consolidation. A further consideration in reviewing production figures and arguments about efficiency in the steel industry are concerns that the apparent 'inefficiencies' are being used as a means by central government line agencies to consolidate industrial production within the state-owned sector (Naughton, 2009c).

It is important to stress that the CEACER report is largely focussed on modelling and analysis of alternative emission projections, rather than the policy making processes and implementation. This critical second stage is now the key focus of the researchers involved in the report with collaboration between ERI and CSES contributing to these dimensions through the three case studies (see separate Final Report). Presently, a key focus of research is on developing feasible and realistic targets developed in cooperation with other developed nations. A remaining constraint exists relating to China's access to comparable international data and global trends, including an examination of the structural issues of the economy. Some of these issues were recently addressed during the 2009 US-China engagement on energy and the resultant cooperation agreements. For example, see the US-China Electric Vehicle Initiative (White House, 2009), which included proposed collaborative activities such as discussions and development on 'joint standards development', 'joint demonstrations' and 'joint technical roadmap'.

[#] The CEACER report is not alone in underestimating growth projections for China. The World Bank, IEA, IMF and OECD predictions for energy consumption in China have all needed to be adjusted regularly. While such adjustments are made in the short-term, very few projections include sustained growth forecasts beyond 2020.

[##] China has rapidly risen up the global steel production ladder from 2000 when it produced a sixth of all steel to now producing almost half of all steel in 2009.

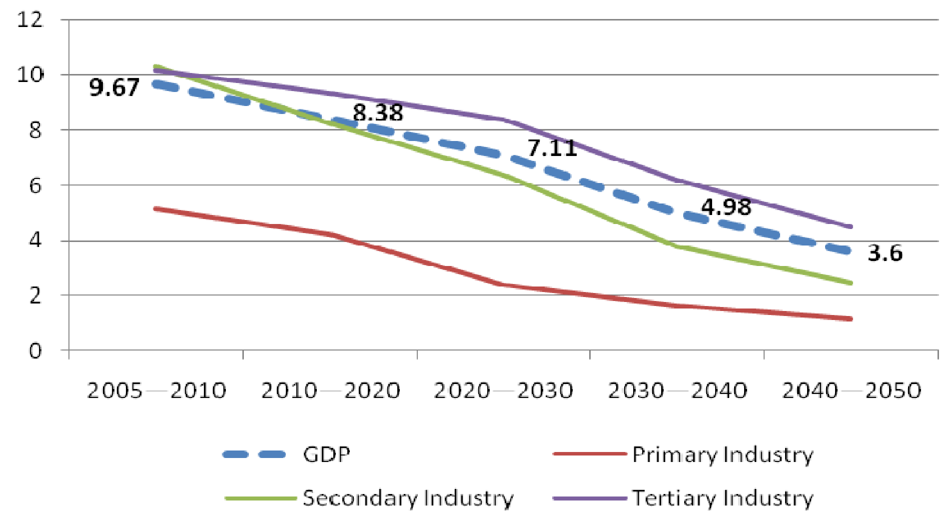
Figure 38: Growth of China's GDP by Sector, 2005-2030



Note: amounts are set at constant 2005 prices.
Source: CEACER, 2009

Rapid GDP growth driven by industrial expansion and urbanisation are the key drivers for China's continuing rapid growth in GHG emissions. According to CEACER modelling, China's GDP is expected to continue to grow at or near 10% per annum for the next decade despite the recent global economic crisis which is predicted to slow its growth to around 8-9% in the short term (see Figure 38 and 39). By 2020, GDP growth may slow to between 6-8% per annum, yet China will account for a quarter of total global economic activity to become the world's largest national economy. This shall increase China's role as the source of global economic growth, especially in driving the demand for resources.

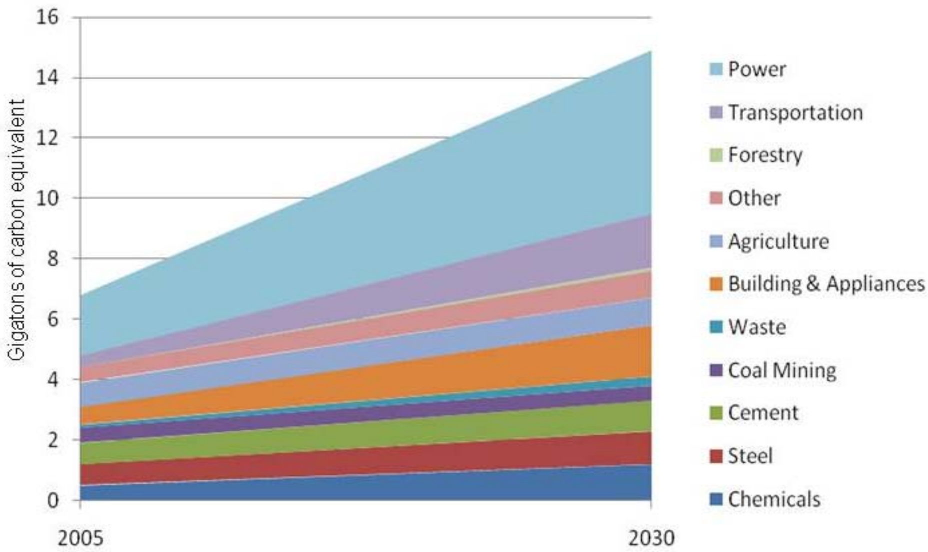
Figure 39: Rate of Growth by Sector of China's GDP (%)



Source: CEACER, 2009

A key consideration for this report is the speed of adjustment within the structure of the economy. For structural rebalancing to take place, the expansion of the service sector needs to be above the growth of the industrial sector. However, predictions that this would occur during the 11th FYP have been premature. By 2020, China will reach middle income status and yet the industrial sector is expected to retain a key role in boosting growth. The pre-eminence of industry will gradually be supplanted by the rapid expansion of the service sector. By 2020, the service sector is likely to gradually increase its share of economic growth from around the present 41.8% to nearly 45%. The shift, as shown in Figures 17 and 18, however, will most likely remain gradual. And yet according to Figures 16 and 18, secondary industry retains its preeminent hold on GDP growth until 2030 when it accounts for over 40% of total GDP compared to around 48% in 2005. By 2030, the service sector is expected to contribute to more than half of the nation's economic value. The gains in the tertiary sector occur as primary industry's share steadily declines to around 4.3% in 2030.

Figure 40: CO_2 Emissions by Sector, BAU Scenario, 2005 & 2030



Source: CEACER, 2009

Figure 40 illustrates the growth in emissions by different sectors of the economy. It shows that the largest growth in China's emissions will come from the three sectors of power generation, transportation, and buildings and appliances. Clearly, power generation remains the most important contributor to emissions – almost tripling between 2005 and 2030. GHG emissions from power generation are estimated to rise from 2.0 Gigatons of CO_2-e per year to 5.4 Gt in 2030; a 170% increase. However, what is also evident is the expansion of the building and appliances, and transport sectors, which make up for much of the rest of the growth. Buildings and appliance are set to triple from the existing 1.1 Gt of CO_2-e per year to 3.2 Gt in 2030; a 190% rise. Whereas the transportation sectors annual contributions are set to rise 350% by 2030. This dramatic rise is due to the existing low base level in China today. For example, in 2005 China's vehicle penetration rate was only 3% compared with 60% in Japan and 80% in the United States. As a result, the transportation sector only contributes around 8% of China's total GHG emissions compared with 22% in Japan and 29% in the US. However, penetration rates are shifting dramatically in recent years with the doubling of vehicle ownership rates between 2004 and 2009 and they are expected to double again by 2015 (Credit Suisse, 2010). Furthermore, expectations of a ten-fold increase in vehicle numbers to 337 million vehicles by 2030, mostly private light-duty vehicles, will dramatically alter this balance. Based on an average annual mileage of 10,000 km, vehicles will emit 1.8 Gt of CO_2-e by 2030 up from existing emissions of 0.4 Gt CO_2-e (McKinsey, 2009, 39).

As a result of the combination of existing policies with the burgeoning growth in the urban population and their insatiable appetite for household appliances, primary energy demand in China is expected to more than triple between now and 2030. According to the IEA (2009a), China shall account for 39% of the global increase in primary energy use between 2007 and 2030 with its share of total global demand increasing from 16% to 23% respectively. According to Figure 41, primary energy demand will grow at just under 3% annually between 2007 and 2030 to reach 3,827 Mtoe by 2030. Final electricity consumption will rise by 4.5% annually during the same period and reach 7,513 TWh.

Figure 41: Energy Scenarios for China

	2001	2007	2015	2020	2030	2007-2030
Primary energy demand (Mtoe)	603	1 105	1 970	2 783	3 827	2.9%
Final electricity consumption (TWh)	259	1 081	2 717	4 723	7 513	4.5%

Source: IEA, 2009a; CAECER, 2009

Regardless of the scenario or predictions for China's future energy use, much of the increase in energy demand through to 2030 remains coal-dependent. China already doubled coal consumption between 2001 and 2007 with expectations it will double once more by 2030 to 3424 Mtce, accounting for around 65% of the global increase in coal use between 2007 and 2030 (IEA, 2009a).

Figure 42: Projected Energy Capacity, Baseline Scenario

	Coal	Petroleum	Natural Gas	Hydro	Nuclear	Wind/ Solar	Biomass	Total (GW)
2000	70.62%	3.01%	0.49%	24.83%	0.71%	0.17%	0.18%	309.04
2005	71.44%	2.54%	0.44%	23.50%	1.66%	0.23%	0.19%	516.24
2010	73.01%	1.86%	1.03%	21.11%	1.39%	0.66%	0.93%	937.45
2020	72.51%	1.64%	2.54%	18.91%	2.02%	1.20%	1.19%	143.01
2030	70.10%	1.35%	4.58%	16.52%	3.33%	2.78%	1.35%	182.75
2040	55.92%	1.36%	8.54%	16.66%	9.04%	6.67%	1.81%	211.91
2050	53.41%	1.38%	10.22%	14.53%	11.83%	6.79%	1.84%	236.12

Source: CEACER, 2009

At the same time, according to the CEACER's (2009) business as usual (BAU) scenario for China's future energy mix, total renewable energy capacity actually declines as a percentage of the total energy capacity due to the growth of low carbon energy sources such as natural gas and nuclear power (see Figure 42). For example, between 2000 and 2020 the proportion of renewables reduces from 25% to 21%. By 2050, nuclear and natural gas increase their capacity to 11.8% and 10.2% respectively while coal's growth stabilises from 2020 above 72% and eventually declines to 53% by 2050.

Figure 43 illustrates the enhanced or aggressive low carbon scenario calculated by the IPAC-AIM technology model, whereby total energy generation capacity peaks around 2030 and eventually declines due to the expansion of nuclear and wind. Hydro power generation capacity peaks by 2020 due to limitations on new capacity when it reaches nearly 30% of total capacity. By 2050, renewables contribute over 43% of China's total energy capacity, but when combined with the low carbon fuels of nuclear and natural gas reaches 70% with coal reduced to around 27%.

Figure 43: Energy Generation Capacity, Enhanced Low Carbon Scenario (billion kWh)

	Coal	Petroleum	Natural Gas	Hydro	Nuclear	Wind	Solar	Biomass	Total
2000	70.62%	3.01%	0.49%	24.83%	0.71%	0.17%	0.00%	0.18%	3090.4
2005	71.44%	2.54%	0.44%	23.50%	1.66%	0.23%	0.00%	0.19%	5162.3
2010	68.12%	1.44%	1.92%	22.59%	2.10%	3.09%	0.05%	0.67%	8431.7
2020	49.46%	0.93%	5.14%	28.95%	5.41%	8.21%	0.12%	1.78%	12743.3
2030	37.66%	0.72%	6.63%	26.85%	9.24%	15.98%	0.59%	2.34%	16604.8
2040	31.30%	0.55%	7.83%	24.81%	12.89%	18.56%	1.69%	2.37%	19653.3
2050	27.19%	0.47%	9.22%	21.57%	17.51%	18.31%	3.48%	2.25%	22184.5

Source: CEACER, 2009

Energy and Development under a Low Carbon Economy

The characteristics of China's reform experience highlight the complex patterns and variations between regions and within various sectors of the economy and society. Such a predicament ensures that making predictions or outlining trends and patterns in such a divergent context very difficult. The ongoing oscillations in the direction and pace of the reforms and the incremental, adaptive and reactive nature of policy developments challenge narrow and linear predictions and projections of future change in China. What is obvious to the state, however, is the implication of ignoring the current imbalances in the economic structure, especially the serious environmental and resource constraints arising from energy-intensive industrial expansion. Moreover, the state perceives an opportunity to tackle the economic and social imbalances through a development path that minimises environmental and resource costs. One suggested approach for resolving the existing economic imbalances and developmental contradictions is a low carbon economy (LCE). This section of the report explores some of the key characteristics of a low carbon economy, as well as how this so-called 'new economy' differs from traditional patterns of development and economic principles. The final part of the report assesses the feasibility of China successfully decoupling economic development from increasing energy and carbon emissions, and concludes with a brief summary of the key issues.

The debate on the low carbon economy has given rise to three sets of issues about its meaning, its significance and its implementation. This section introduces the role of a low carbon economy as a vehicle for rebalancing the structure of China's economy. The significance of a low carbon economy is then discussed prior to discussing the impact of the government's response to the global financial crisis in the form of the economic stimulus package, including the implications of this package for energy sue and economic rebalancing.

The Concept of a Low Carbon Economy

For some the concept of a low carbon economy involves a new economic paradigm, whilst for others it entails a complete social transformation of which the economy is only a part. There is additional debate about the timing and intensity of implementing a LCE with some calling for a gradual adoption of measures, whilst others call for a complete and rapid paradigm shift. Whichever path towards a low carbon economy is chosen, there is a growing recognition that the concept can play a leading role in rebalancing the economic structure of a nation towards a more sustainable development path (CAS, 2009a; GERF, 2008; NEF, 2009; Royal Society, 2009; SEI, 2009; UK Government, 2007; Vivid Economics et al., 2009; Zhuang Guiyang, 2008).

The low carbon economy concept first emerged in the UK government's energy white paper as part of a strategy to reduce GHG emissions and improve energy security (DTI, 2003). A key focus of the concept is the decoupling of carbon outputs and economic development. In other words it aims to reduce the ratio of carbon in energy production and consumption, especially through energy efficiency improvements and is often measured as the level of energy consumption per unit of GDP. Implicit in adopting a low carbon economy is that early action on climate change can mitigate the extreme negative impacts of climate change whilst reducing the economic, social and environmental costs of inaction or delay.[68] Generally, a low carbon economy encompasses several principles, including:

- waste minimisation;
- maximise the adoption of low carbon energy sources and methods, especially renewable and alternative energy sources and fuels;
- ensure the efficient utilisation of all resources, especially energy, through the retrofitting and adoption of leading energy efficiency measures and techniques;
- expand the support for research and development, early stage technological development and the necessary human skills to realise such developments; and
- raise the level of awareness and compliance with environmental and social responsibility initiatives amongst industry, commerce and individuals.

The concept of a low carbon economy emerged in China due to a growing acceptance that the traditional development strategy based upon heavy industrialisation is environmentally and socially unsustainable and economically insufficient to deal with the demands of an increasingly competitive global economy. It is increasingly apparent that China is not likely to continue down the traditional path

[68] Delays in adopting world's best practice in energy efficiency and low emissions technology pose serious challenges for China's energy security as well as for global climate change. McKinsey (2009) argue that a delay of only five years in failing to realise the energy efficiency savings arising from mainly the energy, transport and housing sectors would reduce the potential abatement of carbon emissions through to 2030 by 30%. A delay of 10 years would increase the lost abatement to 60%. Therefore, more aggressive policy measures need to be adopted in China in terms of the transition to a low carbon economy, including strategic planning of cities, promoting renewables and low carbon energy generation, tighter building energy efficiency standards as well as higher fuel economy standards for vehicles.

of economic development, nor will it progressively adopt the institutions, systems and policies prevailing in advanced economies. Instead, new and distinctive approaches to development, which take into account China's local circumstances and the new global realities, need to be urgently implemented. A low carbon economy (LCE) is seen as offering a good mix of policies for rebalancing China's economy towards achieving more sustainable growth (CAS, 2009a; CEACER, 2009). Key arguments for supporting the adoption of the low carbon economy are based upon the premises that it will:

- provide a new competitive advantage for China's manufacturing and industrial sectors within a fundamentally different global context;
- grow employment through productivity gains from quality enhancing process technologies rather than labour-saving technologies;
- rebalance the existing unsustainable use of resources and environmental degradation;
- offer alternative income streams for rural communities and improve rural output;
- significantly contribute to mitigating China's rapidly growing GHG emissions; and
- strengthen China's capacity to adapt to a climate changed globe.

Therefore, the growing calls for adopting a LCE development pattern are well received by government due to the concept fit with the broader desired goals of structural rebalancing.[69] However, much remains unclear in terms of the meaning, scope and implications of a LCE for China, including whether LCE is a development strategy that is compatible with rapid, balanced and sustainable long-term growth. This report shall address some of the key questions that have arisen within the Chinese debate, and in particular explore the relevance of the low carbon economy to China's development strategy.[70] While each aspect of the structural rebalancing issues is of critical importance and interconnected, it is not possible to explore all of the issues in any depth in this report. Therefore, this report is limited to focusing on one major aspect critical to the implementation of such a revised approach – the role of sustainable energy use and its relationship to a low carbon economy.

The Significance of a Low Carbon Economy

An enormous number of decisions about China's future path of development are being made everyday throughout the country relating to the types of buildings erected, the preferable mode of transport, the sources of energy used to power the economy and the types of household appliances to purchase. The decisions made today in China hold significant implications for the nation's development path. Moreover, the world is increasingly aware that decisions made today in China have implications not just for China, but more generally for the globe in terms of the environment, especially climate change, resource availability and prices and developmental opportunities. Given the current state of China's economic structure and projections for future growth, the significance of China embracing a low carbon economy is obvious. Nevertheless, China is set to benefit from this transition beyond achieving a more

[69] There are some vagaries, however, about the similarities and differences between LCE and other concepts in China such as circular economy, sustainable development, ecological civilisation and harmonious and scientific development (Bina, 2009).

[70] See for example Xin Hua (2009), Zhou Shouxian (2009), Huang and Li (2009), Guo and Wang (2009), Hu Ning (2009), Hu Zhenyu (2009)

sustainable path of development, but in attaining new competitive advantages through innovation and technology whilst mitigating its GHG emissions.

Climate change is one of the key challenges of the twenty first century. In response, a global consensus now supports structural economic changes to reduce greenhouse gas (GHG) emissions. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007a), a common but differentiated responsibility for implementing this transformation rests largely with the wealthy governments, firms and citizens of developed nations. The IPCC has called for global action to reduce GHG emissions by 50% to 85% of 2000 levels by 2050 to cap warming by 2 degrees Celsius above pre-industrial levels. Such a rise provides the best chance of avoiding dramatic ecological, economic and social damage from occurring (European Commission, 2007; IPCC 2007b; Stern, 2007). While global action is critical for achieving success, there are growing concerns that if rapidly developing economies, such as China, are excluded from binding reductions, then there is little likelihood of achieving the 2 degree target. According to the U.S. Assistant Secretary of Energy, Sandalow (2009):

> *Even if every other country in the world cut its emissions 80% by 2050 … China's business-as-usual emissions alone would cause global average temperatures to increase by 2.7 degrees centigrade.*

Achieving the 2 degree target will mean changing the way that business is done. The Chinese government is well aware of the need to conserve resources and improve energy efficiencies, but it is similarly committed to rapid economic growth through the quadrupling of per capita GDP between 2000 and 2020 (Hu Jintao, 2007). China has already made serious commitments to improve its energy structure and energy efficiency with targeted reductions of 20% by 2010, the introduction of clean technologies in the energy sector and a reduction of the economy's carbon intensity by 40-45% between 2005 and 2020.

In spite of all the talk, current economic growth remains both energy intensive and carbon intensive (World Bank, 2008; Chatham House & E3G, 2008). Pan Jiahua (2009) warns that 'energy-saving and emissions-reduction are not the same as greenhouse-gas curbs' and that 'different methods of production and lifestyles' are needed in order to have a major impact on emissions:

> *China needs to choos[e] a low-carbon path with improved energy efficiency and a better energy infrastructure, developing clean energy and preventing greenhouse-gas emissions from becoming a barrier to China's economic growth.*

President Hu Jintao, recently echoed these ideas when he argued for the need to tackle climate change on the basis of economic development, and that China must "proactively participate in global cooperation to fight climate change" as well inculcate the whole of Chinese society with the importance of saving energy, reducing emissions and being environmentally aware (Reuters, 2010).

In recognition of the urgent need to decouple China's growing GHG emissions from amount of resources used, waste generated and pollution produced per unit of production, the Chinese government adopted the concept of a low carbon economy. Although the Chinese government acknowledge the economic, social and environmental risks of not responding to climate change, significant implementation gaps remain in turning the rhetoric into implementable policy reality. A recent review of current government and business responses argues that real change is slow to materialize despite strong commitments to future emissions reductions (Economy, 2007b). There is now a broad consensus that without more aggressive and increased policy and market interventions by government, energy efficiencies and carbon reductions are unlikely to be implemented at a rate necessary for meeting global emission reduction targets.

Competitive Advantage

> *China will accelerate the development of a low carbon economy and green economy so as to gain an advantageous position in the international industrial competition.*

This quote from Wen Jiabao's (2009) speech at the World Economic Forum China highlights the increasing realisation of the competitive benefits of adjusting China's economic structure by investing more in higher value added manufacturing as well as reducing the country's heavy reliance upon coal as a source of energy. A LCE is seen as offering China not only the opportunity for rebalancing but for decoupling its heavy reliance upon coal and energy intensive industry as a driver for economic growth. Moreover, China is highly vulnerable to the impacts of climate change (economically, socially and environmentally) and needs to make significant investments in mitigation and adaptation strategies. China can accelerate the transition away from carbon intensive growth as well as strengthen and consolidate its competitive advantages through innovation, science and technology and research and development in new energy developments. There is a growing realisation of the asymmetry between China's current stage of development and a low carbon economy.

> *Humanity can solve the carbon and climate problem in the first half of this century simply by scaling up what we already know how to do.*

Pacala and Socolow (2004) argued that existing technologies offer the best and lowest cost options for decarbonising the economy and reducing GHG emissions. The global pressure to adopt these so-called clean technologies (cleantech) has provided a boost to nations already strong in the application and production of high technology equipment and processes, such as Germany and Japan. According to Ellen Carberry of the China Greentech Initiative (Ford, 2009), "China sees [green technology] as an enormous market that is not claimed or controlled by any one nation, and there is an opportunity for them to do it … The combination of urgency; the enormous needs; a focused, systematic planned government; an army of engineers; and access to capital may define China as the platform for the green- technology industry globally". Moreover, according to Wan Gang (2009), the Minister of Science and Information Technology, China can seize the opportunity arising from the "dual crises" of climate change and global economic recession through a new industrial revolution based upon new energy technologies and industrial structural adjustment with new energy sources and a low carbon economy (China Energy Network, 2009). Similarly, the director of the China Environmental Protection Research Institute, Zhou Guomei, argued that the global financial crisis provides China with an opportunity to consolidate measures in reducing GHG emissions, readjusting the industrial mix, changing the mode of growth and strengthening China's environmental protection measures.[71]

In recent years, China has has announced a string of policy initiatives aimed at shifting towards to a low carbon economy. However, it is not guaranteed global market leadership in the manufacturing of such products or technologies. It will need to maintain strong policy support and market incentives to compete for both hard and soft technological development against a backdrop of state-led investment in so-called 'cleantech' investment. The motor vehicle industry is a case in point with large government assistance programs taking place in the US ($11 billion), Japan ($200 million between 2009 and 2014) and France (over €400 million between 2009 and 2013) for promoting electric vehicles and new battery technologies. As a result, in 2009 the head of China's National Energy Administration, Zhang Guobao said, China attaches great importance to the development of the new energy industry and will closely track the new global trends in this field (Hu Shaowei, 2009). According to Zhang, "China will increase investment in the new energy industry, strengthen scientific research in this field and raise its development to a strategic position". Without such investment, Zhang argued that China would fall behind other nations in this emerging economic sector if it fails to see this issue from a strategic perspective. To increase its international competitiveness, China views the development of the new energy sector as an effective method to boost the manufacturing sector, increase employment and investment and generate higher domestic demand. This has led some to assert that China is in the early stages of a new energy revolution with plans to leap frog from the middle of a heavy industry phase of development into a new technology and low carbon phase (Friedman, 2009).

China can benefit from global technological developments over the past three decades for minimising and managing environmental problems. By gaining access to these technologies, China can skip the intermediate stages in technology and achieve greater short-term improvements than would otherwise be possible. Similarly, advances in policymaking capabilities in the environmental area in rich countries, including better data, management systems, institutional developments and the use of market instruments, can benefit China.

A key component of the development of the clean tech market is that it not only benefits China, but offers significant global benefits, beyond reducing global emissions from China, but reducing the costs and advancing technological development and expansion. China is expected to focus on maximising the competitive and growth potential of climate change more than most other nations. China is already emerging as the largest manufacturer and market for clean tech industries including renewable energy production, such as wind turbines and solar panels. According to a recent industry report (Volans, 2009), China's clean tech market may be worth as much as US$500 billion to US$1 trillion per year by 2013. The Chinese Renewable Energy Industries Association claims the renewables sector employed over one million workers in 2008 and is expanding by 100,000 a year (Bradsher, 2010). According to ERI director, Jiang Kejun, "only by using advanced low carbon technologies can China's greenhouse gas emissions peak around 2030; otherwise, the peak will be delayed and we don't want to see the latter scenario" (Fu Jing, 2009) Moreover, China's strategic economic and developmental interests are at the heart of

[71] http://english.people.com.cn/90001/90781/90879/6727384.html

embracing a low carbon economy, according to Jiang, who believes the world should be sharing the necessary technologies to facilitate this transition.

As part of its overall development plan, China is seeking to achieve global leadership, or at least parity with the leading advanced economies, in science, technology and education. To this end, investment by the Chinese government and other Chinese parties in these areas continues to be very substantial.

Figure 44: Research and Development Spending

	2003	2004	2005	2006	2007	2008
R&D spending as % of GDP	1.13	1.23	1.34	1.42	1.44	1.54
Total R&D (billion RMB)	154	196.6	245.0	300.3	371	462

Source: China Statistical Yearbook, 2009

China's economy is both basic and sophisticated. Basic in terms of low overall income levels and consumption levels, but sophisticated in terms of human and technical capacity. In the period 1995-2006, the gross expenditure on R&D (GERD) in China grew at an annual rate of 18%. According to an OECD report (Schaaper, 2009), in the four years to 2008, China added 666,000 personnel to its skilled researcher base, an increase of 71%. China has around 17000 institutions of higher education with a student population of 25 million, which has increased from 5 million in 2000. The path of spending on R&D in China is provided in Figure 44, both in real terms and as a share of GDP. Given the rapid growth of GDP at about 10% per annum, even a stable GDP share implies that R&D spending is rising rapidly in real terms. After being relatively stable at about 0.6% of GDP between 1987 and 1998, R&D as a share of GDP more than doubled to 1.34% by 2005. The outcome of this growth in R&D is that China currently ranks third on GERD, behind the US and Japan.

Similar exponential growth outcomes have occurred in terms of research output. A decade ago, China's research output was around 20,000 articles. By 2006, it had quadrupled, exceeding publications from Japan, the UK and Germany. Then in 2009, more than 120,000 articles were published by Chinese scholars (Thomson Reuters, 2009). Questions about quantity versus quality are often raised regarding China. And yet, an increasing number of the articles are based upon international collaboration in an ever widening range of areas, especially in areas important for the development of a low carbon economy.

In its long term plan for science and technology for 2006-2020, the Chinese government has declared an intention to double the proportion of China's GDP spent on R&D from 1.23% in 2004 to 2% in 2010 and 2.5% by 2020. Using CAECER GDP forecasts above, Chinese R&D by 2020 will be about RMB4.6 billion in 2000 purchasing power parity prices if China achieves an R&D spending level of 2.5% of GDP, implying an average annual growth over 2004-2020 of 13.6%. Based upon these estimates, China will be a research superpower with R&D spending in 2020 over 45% greater than that of the USA, 60% above that of EU-15 and four times that of Japan. Perhaps more importantly, over 50% of the increase in R&D spending in these four countries/regions between 2004 and 2020 will take place in China. While, remarkable gains have been made during the past decade, it is estimated that R&D spending will reach around 1.58% of GDP in 2009, falling short of the 2010 target. But it seems beyond doubt that, if China's R&D spending continues to increase rapidly over the next decade as planned, then China will displace the historical dominance of North American and European research to play a leading role in global science and technology development.

Given the scale of the expansion of China's R&D capabilities, it is useful to note China's national science and technology research priorities, as expressed in the national plan to 2020. The top ten areas of national focus and priority are shown in Figure 45.

Figure 45: Top Ten Areas of National Focus and Priority, 2006-2020

1.	Energy
2.	Water and mineral resources
3.	Environment
4.	Agriculture
5.	Manufacturing
6.	Transportation
7.	Information technology and modern service industries
8.	Population and public health
9.	Urbanisation and municipality development
10.	Public security

Source: MOST, 2006

In 2009, the Chinese Academy of Sciences (CAS, 2009b) sponsored the development of a long-term strategy for R&D and science and technology. This strategy provides direction in eight areas of R&D with 22 key points emphasising the role of international competitiveness, sustainable development and national security. The document also highlights the development of "new energy" industries and products.[72] The notable feature of the priorities in these two plans, in the context of the present study, is their alignment with the current focus towards a low carbon economy. The question remains however, of how this move is to take place and will it be substantial enough to displace the preeminent role of coal and the energy intensive industries it fuels.

Low Carbon Cities

In 2007, Shanghai and Baoding participated in a low carbon cities program supported by the WWF aimed at reducing energy consumption and carbon emissions whilst supporting economic growth. Baoding has utilised its human and technical resources as a major power industry manufacturer for attracting renewable energy manufacturers, such as Yingli Solar and Guodian Wind Turbines. It has also opened up a so-called new energy industrial park called "Power Valley" (following the Silicon Valley model) with incentives, such as reduced taxation and access to soft loans. According to local officials, 500 MW of solar and 5.1 GW of wind power capacity were manufactured in Power Valley by 2008. By 2009, around 20% of the city's GDP was produced by the so-called "new energy sector', which also experienced a 40% growth rate. As a result, local officials declared a new industrial revolution focused on low carbon energy. Following the success of Baoding, a dozen other cities, including Shenzhen, Tianjin, Zhuhai, Nanchang and Wuxi have declared themselves as 'low carbon' to capitalise on the rapid growth in the demand for renewable energy generation components, such as wind turbines, power

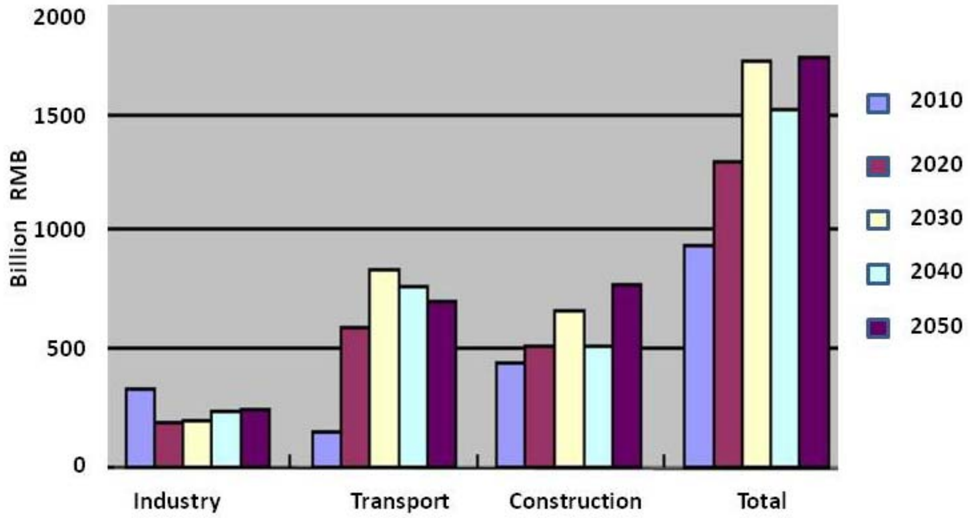
[72] The CAS (2009b) strategy is called: *Innovation 2050: Science and Technology and China's Future* or in Chinese 《创新 2050：科学技术与中国的未来》

generators and solar cells both internationally and domestically. Since the global financial crisis, concerns have been raised about over capacity arising from the rush into renewable and low carbon manufacturing (Dyer & Lau, 2009).

Financing a Low Carbon Economy

According to CEACER estimates of the necessary investment for implementing the 2050 low carbon scenario path, ERI concludes that China needs to spend RMB40 trillion from 2010 to 2050 on advanced technology and energy efficiency measures to reach the targets in the enhanced low carbon economy. This is equivalent to a figure of around RMB1 trillion annually from 2010, incrementally rising to just under RMB2 trillion by 2050 (see Figure 46). According to the modelling, the highest levels of initial investment are necessary in the construction and industry sectors, whereas transportation requires the highest levels in the period 2020 to 2050.

Figure 46: Additional Investment Required to Achieve the Low Carbon Scenario



Source: Jiang Kejun, 2009

When comparing investment levels between the CEACER low carbon and business as usual scenarios there is surprisingly very little difference. For example, investment in the energy industry is around 5-10% higher under a low carbon scenario compared with BAU.

The 2009 *IEA World Energy Outlook* conferred with the CEACER report's conclusion. The IEA estimated that the expected extra energy demands requires an estimated RMB20 trillion investment to build a further 1326 GW of power generation capacity through to 2030. Similar outcomes are reached in the analysis for national energy costs. To provide a cost comparison, McKinsey (2009) analysis estimated that to readjust the energy mix and achieve comparable reductions in CO_2 emissions with ERI's low carbon scenario by 2020, China will need to incrementally invest RMB1.5-2 billion annually over the next two decades. A Renmin University study reported the higher figure of around RMB3.2 trillion annually by 2030 if China continues along its current policy trajectory.[73] The report found that the cost of curbing

[73] China Daily 2009 China's green bill, 3 Sept, 8: Accessed 3 November 2009 online: http://www.chinadaily.com.cn/opinion/2009-09/03/content_8649589.htm

China's GHG emissions will amount to around 7.5% of the country's annual GDP. More modestly, the IEA's *World Energy Outlook* estimated the cost at around RMB280 billion annually through the period 2010-2020 (IEA 2009a). Jiang Kejun et al. (2009) found that investment levels are overall higher in the BAU scenarios than the low carbon scenarios due to the savings made in achieving energy efficiency improvements as well as in realising the lower abatement and adaptation costs. Moreover, Jiang argues that introducing new energy and clean technology industries will be cheaper than upgrading old, inefficient ones, as well as provide greater social and environmental benefits.

The Role of the Global Financial Crisis

> *The unprecedented global financial crisis has taken a heavy toll on the Chinese economy. Yet we have risen up to challenges and dealt with the difficulties with full confidence... However, the stabilization and recovery of the Chinese economy is not yet steady, solid and balanced* .
>
> Wen Jiabao, 2009

In response to the economic turmoil created by the Global Financial crisis, China launched what is widely acknowledged as a 'timely', 'substantial' and 'effective' fiscal stimulus package in November 2009 (Naughton, 2009b; World Bank, 2009; ADB, 2010). The government's RMB4 trillion stimulus package is equivalent to approximately 15% of China's GDP.[74] The stimulus plan contains four strategic goals, which generally reinforce the goals of the 11th FYP:

1. Rebalancing the economy: develop a long-term growth strategy increasingly led by domestic consumption rather than exports.
2. Efficiency: modernise and restructure industry to achieve higher productivity and efficiency.
3. Social balancing: strengthen and expand social welfare and employment.
4. Stability: maintain the broad goals of the economic reforms.

Spending was to be spread over two years, but has been frontloaded with RMB120 billion in spending during the fourth quarter of 2008, a further RMB110 billion in the first quarter of 2009 followed by RMB908 billion in mid-2009. The World Bank (2009c) estimated that government-directed spending lifted GDP growth by over 4% points or more than half of GDP growth in 2009. In contrast, the State Council estimated that the stimulus contributed to between 1.5% and 1.9% to national economic growth. The cost of the plan is expected to produce a record budget deficit of nearly RMB1 trillion in 2009 (less than 3% of GDP) compared with Y180 billion in 2008.

Key aspects of the stimulus could be summarised in three points.

- Firstly, undertake aggressive fiscal stimulus, especially in rural areas, with lower taxes on motor vehicles, property sales and household appliances.
- Secondly, loosen monetary policy to increase access to credit, especially for small and medium companies (SMEs) and individuals. For example, in the property sector, banks have been instructed to accept smaller deposit requirements and lower loan rates for first-time buyers. The

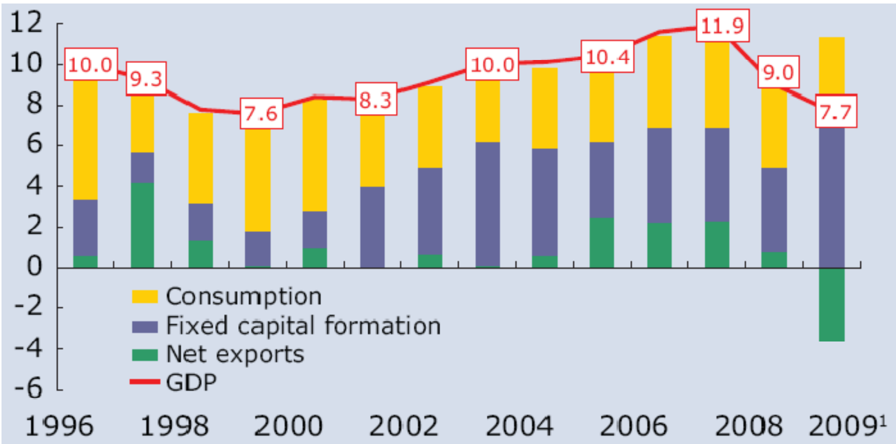
[74] According to Naughton (2009a), direct central government allocations are projected to be equal to around RMB1.18 trillion allocated over 2009-2010, which is equivalent to around 2% of additional fiscal allocations. The remainder of the RMB2.82 billion is expected to come from local governments and banks.

monetary policy resulted in a dramatic expansion of credit. In the first quarter of 2009 bank lending increased to about RMB5 trillion (US$732 billion), almost three times the levels reported during the same period of 2008. By the end of 2009 new bank loans reached nearly RMB10 trillion or more than doubling the RMB4 trillion in 2008. The World Bank (ibid) expects overall loan growth for 2009 of around RMB10 trillion or 40% of GDP. It was reported that in the first week of January, bank lending totalled RMB600 billion due to concerns that the government was planning to reverse the loose monetary policy to avoid a lending bubble.[75]

- Finally, instruct state-owned enterprises to boost production. The package has so far resulted in China avoiding a serious economic downturn with its economy rebounding faster than any other large economy. In November 2009, the World Bank (ibid) raised its forecast for China's GDP growth in 2009 to 8.4%, which is up from its earlier prediction of 6.5%. The main driver for the rebound, as illustrated in Figure 47, has been a "surge in bank lending and vigorous fixed-assets investment" (ADB, 2009).[76]

In early 2010, China's deputy Prime Minister Li Keqiang argued that during the financial crisis China 'spared no effort in rebalancing the structure of the economy' (Pilling, 2010). If we accept this argument, then the Chinese government will need to review its current suite of policy measures, because the economic stimulus program appears to have reversed early gains in structural economic rebalancing. This is particularly obvious in terms of investment levels in energy intensive industries, such as steel, cement, chemicals and manufacturing, which have locked the economy into a cycle of ongoing investment commitments so as to avoid the emergence of crisis levels of bad debt and overcapacity (Yu Yongding, 2009).

Figure 47: Contributions to GDP Growth, y-o-y, %



Note: 1. 2009 figures are for first to third quarter results only.
Source: Cited in ADB (2009) from NBSC

[75] In fact in mid January 2010, the Chinese central bank raised the reserve requirement half a percentage point to 16% for large banks and 14% for smaller banks. The decision to require banks to hold more internal assets was apparently in response to concerns of a stock and housing bubble (Wines, 2010).

[76] According to the National Bureau of Statistics (http://www.stats.gov.cn), between January and November 2009, China's industrial production increased 10.3% year-on-year. This suggests that domestic demand remains robust.

Accompanying every financial crisis is a revolution in technology that serves as an engine for economic development. This time, new energy technology will probably be the new driving force.

China's Science and Technology Minister, Wan Gang April 2009[77]

According to the Science and Technology Minister, China should emerge from the global economic crisis greener and more advanced than it went in. Despite powerful statements about the "greenness" of China's stimulus with the government's initial allocation of RMB350 billion or 9% of the stimulus for the environment, it seems that around RMB21 billion had been disbursed by June 2009 or just 0.5% (Horn-Phathanothai, 2009). The key issue in the stimulus is not in fact the environmental component, but the potential opportunities of "greening" the broader stimulus, in particular the infrastructure programs including the Sichuan reconstruction, housing scheme, railways and power grid spending components. Utilising the stimulus package to foster innovation, research and development as well as science and technology for strengthening the new energy economy would have not only strengthened the momentum for rebalancing development but provided the economy with a competitive advantage. If, for example, the new buildings and homes being built incorporated energy and water efficiency benefits, or the power grid linked up renewables into the electricity network and the railways funding boosted public transportation systems, then HSBC estimates the stimulus could be 37% green (HSBC, 2009).

It appears that the stimulus package has been fundamentally utilised for boosting economic growth rather than as a catalyst for redirecting the economic structure away from high-levels of investment in export-orientated manufacturing and heavy industry. Despite the apparent lessons arising from the last major economic stimulus program following the Asian Financial Crisis, local governments and bankers have returned to what they understand best - maintaining rapid economic growth.

Disappointingly, a large portion of the stimulus funding seems to be cyclically rather than structurally focused. As a result, much of the stimulus package is being funnelled into the "old economy" with infrastructure and project funding supporting projects initially rejected due to their negative environmental and resource implications.[78] For instance, NEA head, Zhang Guobao (People's Daily, 2010), noted that "some local governments approved energy-guzzling projects during economic crisis". Moreover, due to the 'hard wiring' of the financial system, much of the new lending has gone into supporting energy-intensive SOE construction, manufacturing and infrastructure industries (Horn-Phathanothai, 2009). This is obvious in the recent production data for steel, iron and cement which have expressed strong growth throughout 2009 despite the global economic downturn.[79] All three products have been boosted by the rebound in the property market, the strong infrastructure component of the

[77] Cited in http://www.guardian.co.uk/environment/2009/apr/02/china-e6-electric-car

[78] This is epitomised by the scaling back of the EIA process through a fast-tracking system, ironically described as the "green passage" 绿色通道 (Wang Xiaojun, 2009). This was a major set-back for the newly promoted Ministry of Environmental Protection which was only just granted vetting powers over major investment projects as part of the 2008 administrative reforms. This was a strategic shift away from the local-level environmental protection bureaus which were heavily influenced by local government priorities.

[79] According to Horn-Phathanothai (2009) "crude steel output in China rose to a record 266.6 million tonnes in the first half of 2009, as the stimulus spurred demand from the construction and automobile sectors".

stimulus and the rapid growth in automobile sales. For example, new lending investment to the property sector in 2009 increased by 40% over 2008 figures. Ironically, in response to concerns about investment resulting in asset bubbles and non-performing loans, in late 2009 China's Banking Regulatory Commission adjusted lending rules to discourage speculative lending and stabilise bank risks. Concerns about over capacity in the industrial sectors affecting energy efficiency targets, emission forecasts, stable economic growth projections and falling prices have been raised by the State Council which issued a new plan to reduce overcapacity in seven key industries (Dyer & Lau, 2009). However, it is still too early to see if the adjustments to monetary lending will curtail the speculation or effective curtail lending to and investment in "sectors with overcapacity and high-energy-consuming and high-emission industries".[80] According to Huang Yiping (2010), China's monetary policy remains constrained in several ways, including: the absence of a special policy-formation mechanism with clearly defined responsibilities; a lack of consistent targets; an over-utilisation of 'irregular' policy tools and measures, such as 'moral persuasion' and credit controls; and a reluctance to utilise conventional tools such as exchange rates and interest rates. What is clear however, is that the ongoing tweaking of the economy is primarily targeted at providing "a stable and relatively fast" economic growth[81] through the "continuity and stability" of macroeconomic policies, including loose monetary policy. The implication for economic structure and the rebalancing program is, on the one hand, offering reassurance that national policy priorities will remain focussed on achieving rapid economic growth, whilst gradually adjusting the economic structure to shift the key driver of the economy towards the service sector. Due to inherent and ongoing weaknesses in the global economy, it is most likely that earlier calls for more ambitious rebalancing policies during the 12th FYP will be restrained. At the same time, there is a growing acknowledgement within China that policies promoting domestic consumption are concomitant to strengthening growth and rebalancing the economy. The question remains, however, whether such adjustments are sustainable from a resource and environmental perspective.

[80] Statements made in late 2009 by the NDRC revealed a growing transparency and level of detail in industrial policy, especially in making clear statements about closing down new investments in areas experiencing over capacity and the promotion of other industrial sectors such as nuclear, bio-technology, IT and bio-pharmaceutical (People's Daily, 2009; BoA & Merrill Lynch, 2009)

[81] This was the message emerging from the Central Economic Work Conference (CEWC) in Beijing in late 2009 and echoes the same message in 2008. The CEWC is an annual gathering of the nation's top leaders to map out economic policy measures for the following year.

Implementing a Low Carbon Economy: From Inertia to Realising Opportunities

The domestic and international significance of China making the transition to a low carbon economy is considerable. However, the task in shifting the economy is enormous and therefore for it to be successful there is a need for both aggressive policy action combined with international assistance, particularly in the area of sharing best practice policies and energy efficiency and affordable low carbon technologies. The preceding sections of this report have explored the reasons for rebalancing China's economic structure including the remaining challenges; the relationship between China's energy use and current and future emissions; and, the role of low carbon economy in decoupling economic growth from increasing carbon emissions, whilst providing China with a new opportunity for sustainable economic development.

> *We should make carbon reduction a new source of economic growth, and change the economic development model to maximize efficiency, lower energy consumption and minimize carbon discharges.* (NPC, 2009)

As articulated in this NPC (2009) resolution, the key is realising the benefits and opportunities arising from a low carbon economy, especially through implementation at the local level. However, before this is possible, China needs to adjust the current pattern of economic development, including the key drivers and incentives for the ongoing unsustainable mode of emphasising quantitative growth over quality development. It is increasingly apparent that the rebalancing of China's development requires deeper reforms beyond structural economic adjustments and new technology. Instead, it should extend to reviewing the concept of development itself.

China needs to redefine development beyond existing simple measure of economic expansion, which externalises many economic, social and environmental costs. The current attachment to GDP is not a problem in itself, however the political imperative of this indicator in prioritising government decision-making is inappropriate, especially considering its weakness in measuring overall social development and economic health. GDP is further limited in its ability to incorporate medium to long-term economic considerations, such as the value of pulped timber versus forests for water protection, biodiversity and as a carbon sink. Moreover, GDP fails to clearly distinguish between productive investment and extravagant squandering, nor account for over-valued property and fuzzy derivative values. Previous attempts at adopting alternative measures, such as a Green GDP were too confronting for a regime that prefers no news, to bad news. The Green GDP figure revealed negative development in some areas due to the high costs of the previously hidden pollution and health (Bjureby, et al., 2008; Economist, 2008c). The recent global financial crisis has reinvigorated the debate about the limitations of GDP as a measure of development. Recent international-level work on reviewing developmental indicators and statistics to try and formulate a better measure of progress has been undertaken by French Government,[82] the European Commission[83] and the OECD.[84] However, moving away from GDP's paramount role will remain

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[82] The 'Commission on the Measurement of Economic Performance and Social Progress' report is available at: http://www.policyinnovations.org/ideas/innovations/data/000144/_res/id=sa_File1/economicperformancecommissionreport.pdf

[83] In 2009, the European Commission set up the 'Beyond GDP' initiative (http://www.beyond-gdp.eu).

difficult especially in China where most local governments and industries prefer the illusion of economic growth, because a clearer indication of social, environmental and economic progress may not be in their interest. Naughton (2009a, 7) provides a sobering warning about the challenge of departing from existing mode of development and more specifically the role of local governments in particular in not just slowing down the rebalancing program through the stimulus program, but in fact bringing it to a halt:

> *The problem is that so far there is little evidence of any significant political will to really change the patterns embodied in last year's growth. On the contrary, there are strong political forces that benefit from government patronage and extension of government power, and those interest groups do not show the slightest sign of being in retreat. The Chinese government, headed by Premier Wen Jiabao, has made many statements about their intention to move toward more balanced growth, since at least 2004. But it hasn't happened.*

This report has introduced a wide range of comprehensive and significant steps China is making towards adjusting its economic structure, especially in regard to energy generation, use and conservation. Shifting away from a coal-based energy and resource intensive pattern of development will require time and significant structural adjustments for alternative pathways to be realised. These efforts have been globally recognised as the most ambitious in the world and for transforming China into a green economic giant and global leader in alternative energy investment (The Climate Group, 2009; UNEP, 2009; Ford, 2009). What is evident is that the Chinese government has been seeking a cleaner less-polluting and less intensive pattern of development for the past thirty years. In general, it has successfully reduced pollution, waste and energy as a unit of GDP. While the post-WTO entry period witnessed a reversal of the steady improvements in reducing the energy intensity of the country's economy, what is increasingly apparent is that China has commenced the transition towards a low carbon economy. In summary, this section firstly introduces several of the key policy measures that stand out in this regard prior to highlighting ongoing structural and implementation challenges and finally offering some suggestions for strengthening existing measures.

China has initiated a comprehensive process of substantial and comprehensive policy support for a low carbon economy. This is probably most apparent in the renewable energy sector. The rapid growth in the manufacture and installation of renewable and low carbon energy production, especially wind, hydro, biomass, solar, nuclear and natural gas, reveals the momentum behind China's transition to a low carbon economy. Initially ambitious targets for low carbon energy generation, such as wind, solar, hydro, biomass and nuclear, have all been met and then raised even higher. At current growth rates, low carbon energy sources are expected to represent over 15% by 2020 and around 30-40% of the energy supply by 2050.[85] In addition, the target of installing solar hot water systems on one third of houses by 2020 is likely to be met early. The growth in the renewable sector has taken place following targeted government investment as well as supportive policy measures, such as feed-in tariffs and the direct payments covering grid connectivity for setting up wind, solar and biomass power plants. As a result of

[84] Since 2007, the OECD has hosted the Global Project on 'Measuring the Progress of Societies' (www.oecd.org/progress).

[85] http://english.peopledaily.com.cn/90001/90778/90857/90860/6650353.html

these policies, China is now the leading manufacturer of solar cells and wind turbines (Bradsher, 2010) and will most likely become the global leader by 2015 in terms of spending in the cleantech sector, including renewable generation capacity and manufacturing.

The expansion of the renewables sector has not just focussed on manufacturing and expanding markets, but has involved the investment of resources in expanding the skills base and environment for innovation. Premier Wen Jiabao (2009) recently promised to "make China a country of innovation" with science and technology leading development. Today, China is once again a global research and scientific leader. The past decade has witnessed, exponential growth in research and development spending from both the public and private sectors based upon domestic and international collaboration. This has resulted in China utilising and developing world's best practices and state of the art technology in energy production, generation and use. Highlights include the manufacture of highly efficient solar cells, the building of third generation nuclear power plants, the operation of super-ultracritical coal fired power plants, trialling of commercial carbon capture and storage, construction of ultra-high voltage transmission lines for the national grid, the widespread use of cogeneration heat and energy systems in industry and the power sector, and the development of new energy storage devices. The commercialisation of new energy sector innovation continues to be a key focus of government policy and an attractive incentive for the private sector. For example, the sale of over 100 million electric bikes in China during the past five years has provided essential support and commercial opportunities for expanding the battery and electric vehicle sector.

The failure to price the economic, social and environmental externalities of resources and their use is considered as one of the main drivers of energy intensive industrial expansion. However, during the past five years price adjustments to energy and key natural resources have gradually commenced promoting energy conservation and waste reduction. For example, the perverse subsidies and soft pricing of goods produced in resource intensive industries is being phased out. The electricity scheduling reforms for electricity grid companies also prioritise sources of low carbon energy generation. Further reforms to price controls on resources and energy are gradually occurring, including a greater role for the market in determining prices. Raising electricity prices to industrial users and reducing natural gas price subsidies for fertiliser production are two recent initiatives. Such price adjustments need to be gradual due to the risks of inflation affecting social stability. On the demand side, lower taxes for smaller more efficient vehicles has shifted the sales and production of vehicles away from large to small vehicles. Furthermore, the recent introduction of a fuel tax and trialling of an environmental tax offer the opportunity for consideration of a carbon tax in the next few years.

The inclusion of energy efficiency targets in the 11^{th} FYP and local government performance evaluations have been a key focus of government efforts. The arrangements for incorporating energy conservation programs and targets within the performance evaluation of government officials will ensure a higher level of policy implementation. In contrast to most developed economies, China is targeting the major energy-intensive sectors and individual energy users for significant reductions in energy use, energy intensity and carbon emissions. Policy measures include a broad range of incentives and penalties to increase implementation and compliance. The successful and early implementation of two key industry policies, the Top 1000 Program and the Top Ten Energy Conservation Projects are good examples of such an approach and highlights the government's focus on maintaining the economy's global competitiveness whilst achieving energy efficiency. However, ensuring the reliability of statements of compliance with industrial energy efficiency programs has been an ongoing challenge in China. However, more regular and tighter monitoring and auditing of energy use and waste levels including the use of online publication of results as well as increased penalties for the failure to comply or supply of inaccurate data have had a noticeable impact upon higher compliance and implementation rates. Additional improvements in the collection, processing and reporting of energy data though would be beneficial for strengthening compliance.

The government has also revealed a high-level of flexibility and adaptation to policy weaknesses, especially in light of fluctuating domestic and global conditions. The post-2007 strengthening of the programs for meeting the 20% reduction in energy intensity during the 11^{th} FYP epitomizes this approach. Far from being a 'business as usual' policy measure (as argued by some), the success of the energy efficiency targets have compensated for failures in readjusting the economic structure away from energy-intensive industry and high levels of investment in fixed capital. From 2010, China's energy efficiency policy translates into reducing China's annual CO_2 emissions by 1 billion tons from BAU. In contrast, the EU will only reduce its carbon emissions by 300 million tons under the whole period of the Kyoto Protocol. Moreover, the 2009 announcement of extending this program into achieving a 40-45% reduction in carbon intensity by 2020 should also be seen as a significant policy move given the failure to achieve global consensus beyond the Kyoto Protocol. Based upon current policies it appears likely that China will be able to strengthen this target and may even be able to meet a GHG emissions peak and decline scenario from 2030.

A key prerequisite of reaching an early peak and decline scenario is tackling structural change and energy use in the industrial sector. Therefore, continued sectoral programs to meet sector and product targets for energy efficiency as well as the closure of smaller, inefficient modes of industrial production are of critical importance. Ongoing government and banking sector financial support in offering soft loans and other incentives for the upgrading of equipment and retrofitting to achieve energy conservation and waste reduction are important. As are social considerations, especially improvements in the occupational health and safety in manufacturing and mining sectors, with a focus on coal. But critically, central government measures to reduce the growing levels of investment in expanding industrial capacity in energy-intensive sectors needs to be tightened.

China still has some work to go before meeting world's best practices in energy use, but significant steps have been made towards alignment with world leading (EU and Japanese) energy efficiency and pollution standards for industrial production, energy generation, buildings, household appliances and fuel emission standards. Since 2007, industrial programs have improved the energy efficiency of China's coal power generation fleet beyond the equivalent efficiency of US plants. In addition, building energy efficiency codes have resulted in almost 100% of new city-based buildings complying in the design stage and around 80% of newly built buildings meeting the codes. The 150 million compact fluorescent light bulb program is another successful example that has met its targeted goals early. Combined with the enforcement of the indoor heating and cooling program to keep winter heating to 20 degrees and summer cooling at 26 degrees, China has significantly reduced the energy demands and waste in the buildings sector. These programs have been especially successful in the government sector.

Ongoing state-led interventionist programs combined with mandatory targeted reductions in energy intensity and energy efficiency seem to be more successful since 2007. Ongoing strong national monitoring and auditing of local government progress is necessary though to convince China's current and emerging leadership of the importance of the low carbon economy. Local governments and the SOE industrial sector have noticeably shifted the priority of decision making towards energy conservation following the inclusion of energy intensity targets in their annual performance reviews. A key driver behind this shift is a realisation that failure to meet energy goals will now affect their career opportunities (Xinhua, 2010).

Local governments have also been proactive in signing up to the eco-city concept to improve land use and planning so as to reduce energy consumption and strengthen environmental protection. One aspect of this program has been the establishment of low carbon zones across the country to attract investment in the rapidly growing 'cleantech' sector, such as the manufacture of renewable energy generating equipment and R&D in new energy industries. To date, over 40 Chinese cities have announced eco-city or low carbon development zones. These cities have committed high-levels of investment in, and the prioritisation of, rapid mass transit as well as inter-city express rail for passengers and freight. Another important aspect of transport policy has been the new energy motor vehicle program, which offers clear industrial policy priorities with plans for the production of half a million hybrid and electric vehicles by the end of 2011. The roll-out of new energy vehicles is supported by 20 major cities, which are committed to the initial piloting of the program by rolling out the necessary infrastructure, such as new bus, government and taxi fleets or battery charging stations for private vehicles.

Despite these significant steps towards improving energy efficiency and embracing a low carbon economy, China remains at the early stages of the transition. The pattern of development continues to be driven by rapid growth, especially in the heavy industry sector of the economy, which is energy and resource intensive. As this report argues, significant limitations and impediments remain pertaining to changing the fundamental economic structure of growth as well as the institutional system that supports the pattern of growth. Such changes will only be forthcoming if they are in line with the Chinese social, economic and political reality; a reality that is primarily concerned with maintaining stability and the ongoing rule of the Chinese Communist Party. In the short-term context, global commitments to reducing GHGs are secondary considerations and will only occur if they complement the nature of domestic priorities for economic growth. In fact, it is increasingly apparent that such a rebalancing is unlikely to occur until 2020 due to the ongoing gap between the rhetoric of central leaders and their national policy on the one hand, and local implementation and existing lock-in effects of current economic, social and political commitments.

Current economic policies commit China to another decade of rapid construction of new highways, railways, electricity generation capacity, distribution and grid systems, and commercial and residential buildings. Much of the required steel, cement, chemicals and glass will continue to be sourced from an ever expanding energy and resource intensive domestic industrial production base. The industrial expansion in the coming decade will occur side-by-side manufacturing growth for new and existing export markets as well as rapidly growing domestic demand for household items and motor vehicles purchased by the growing incomes and lifestyle expectations of predominantly urban consumers. Combined with a strong reliance and commitment on a carbon-based economy, energy efficiency gains will reduce intensities, but not curtail the rapidly increasing GHG emissions. One of the most significant constraints for adjusting China's energy policy remains the dominant presence of coal in China's energy mix. For instance, China consistently states that its dependence on energy derived from coal will not alter in the near future and that reductions in GHGs will be "rather difficult" to achieve (State Council, 2008). In line with estimates for a tripling of GDP, China expects to double its energy demand to reach around 5.5 to 6 billion tce by 2030. It is expected that coal will remain the key ingredient in China's energy mix. Due to the prevalence of coal in China's energy mix, the nation's carbon dioxide (CO_2) emissions per unit of energy are much higher than the world average level. However, the gradually increasing presence of non-carbon and low carbon energy sources is noteworthy. In addition, the low carbon energy sector has received a significant boost in recent years from supportive domestic policies and rapidly growing domestic and international markets.

As always, the real challenge for China remains delivering actual results through effective policy and program implementation. This is clearly illustrated by the poor progress in achieving energy efficiency improvements during the past four years. Therefore, the implementation of energy efficiency policies must be accompanied by credible systems of monitoring and review, which are based on standard definitions, data classifications and reporting procedures. Unless the output generated by these systems is utilised in designing reform proposals, the participants would soon lose interest in maintaining such systems and the commitment of government leaders would diminish. It is important, therefore to keep the policy cycle (for instance, formulation, implementation, monitoring, review and reform) fully operational in all dimensions.

While China has made increasingly strong political commitments to changing the economic structure and rebalancing the economy, the challenge of implementation remains dependent upon local circumstances as well as the unforeseen changing social, political and economic context at a domestic and global level. The commencement of this project coincided with one of the most disruptive and unanticipated financial dislocations of the past sixty years. If anything has been learnt from this so-called 'global financial crisis', it is the need for a more humble approach to modelling, scenario building and predicting change. Moreover, many of the energy and economic forecasts produced over the past decade pertaining to China have been consistently inaccurate in underreporting future economic growth and emissions.[86] While one positive feature of the GFC has been a slow-down in global carbon emissions, the same cannot be said for China. Beijing's economic response to the GFC has been both swift and comprehensive in form and content. The outcome it appears has been an intensification of China's 'old'

[86] Economic, energy and emission forecasts for China since 2001 from the World Bank, International Energy Agency, United States Energy Information Administration, OECD and Asian Development Bank have largely under estimated the resilience and strong growth of China's economy. As a result, many of the models and scenarios have needed regular updating, but also remind China watchers of the need for caution when accepting predictions for the direction of China's economy.

economic paradigm: high levels of investment in energy intensive heavy industry and infrastructure. Therefore, further, and more aggressive, structural economic change is necessary.

In order for China to realise the low carbon economy, it needs to continue to strengthen measures in five key areas, namely: optimise the economic structure in line with concepts such as clean production and circular economy; embrace low carbon technologies; improving governance and decision-making processes; adjusting social expectations for low carbon living standards; and, strengthening international agreement and cooperation.

1. *Optimising the economic structure to support sustainable energy use and transition to a low carbon economy.*

This involves several considerations:

   a. Continuing energy efficiency gains across all sectors through tightened energy and emission standards, targets and intensities, as well as the expansion of cogeneration, waste recovery and recycling requirements and processes.
   b. Balanced investment in hard and soft infrastructure. Hard refers to the transport system, water provision and treatment, energy grid and housing. Soft infrastructure is the human resources, such as the education, research and development, health, employment conditions and social welfare.
   c. Continue to increase investment levels in research and development spending as well as focus on assisting the commercialisation of new technologies and innovation.
   d. Advance the concept of circular economy for products and modes of production by reducing waste and measuring the full life cycle costs and benefits.

2. *Embracing low carbon technologies*

Policy and technological measures, both in the short and the medium term, need to be better linked. Low carbon technologies should be embraced through industrial innovation, research and maintaining global competitiveness and global market integration. In addition, the utilisation of existing low carbon technologies in industry, buildings and transportation sectors as well as the development of new technologies needs to be further promoted. Rhetoric is strong in this area, but practice on the ground continues to lag with increasing risks of the 'lock-in effect' of buildings and transport systems requiring increasing levels of imbedded energy and for utilisation. The shift towards renewables and low carbon energy generation, including wind, hydro, biomass, nuclear, natural gas and ultracritical and super ultracritical coal fired power plants requires further strengthening at the local level, including support for the export of these technologies to other developing economies.

3. *Improving governance and decision making*

This report has highlighted the gap between central and local governments as one of the most persistent challenges for achieving the rebalancing of development and structural economic adjustment. Moreover, it is expected that the greatest resistance to changing the status quo will continue to come from local governments, which for the most part operate on a simple strategy of seeking rapid levels of GDP growth as a driver of development. Therefore, strengthening local and regional institutional capacity is an important aspect of achieving structural adjustment and facilitating the transition towards a low carbon economy. Under the current political system, the role of leadership is central, especially the system of performance evaluation of local governments, state firms and their individual leaders. Better informed and skilled leaders are therefore needed to be involved in higher levels of integrated decision making and policy development as well as ensuring compliance. Further gradual reforms to the administration of the policy and regulatory system would be beneficial, as well as greater scope for the use of market-based mechanisms in achieving a low carbon economy and removing existing impediments, such as perverse subsidies.

4. *Adjusting expectations for* low carbo*n living standards*

Improving the application of energy efficient technologies and setting up supportive policies for the sustainable use of energy are critical ingredients in shifting to a low carbon development pathway, but due to the size of China's population and the growth of its economy more fundamental changes will be necessary. For example, China may have the largest electric car fleet on the planet by 2030, but can its cities transport system, air quality and energy systems cope with 400 million vehicles. The average quality of life of most households is set to double in the next decade. Therefore, there is an urgent need to emphasise the importance of behavioural change by adjusting lifestyle expectations and raising the level of awareness of energy efficiency and the benefits of low carbon development. Such behavioural change will require an increasing willingness to involve the general public in urban planning, awareness campaigns and behavioural changes through consultation, engagement, monitoring and the media. But critically, effectiveness in shifting expectations requires strong behavioural signals reinforced through pricing systems to promote energy conservation and the responsible purchase and use of energy efficient appliances and products, such as motor vehicles and air conditioners.

5. *International agreement and cooperation*

China's strong actions on adopting a comprehensive range of measures for achieving sustainable energy use provide a clear indicator of the country's priorities. While rapid economic growth will remain the number one goal of government, what has changed is the development pathway. No longer are environmental degradation, energy wastage, air pollution and carbon emissions acceptable corollaries of economic growth. The key driver for change is the acknowledgement that achieving energy security and competitive economic advantage are two sides of the one coin. The bonus is that the low carbon pathway will provide both of these goals together with improved environmental protection and reduced carbon emissions. No doubt, many challenges remain in shifting China's massive economy away from the current energy intensive, industry and investment led growth pattern and onto a low carbon pathway. Much of this will depend upon the successful implementation of broader, integrated and more aggressive social, economic and political reforms than are currently underway to ensure that future growth is more equitable, balanced and sustainable. It is important to recognise the importance of the current shift in China's pattern of development. The nation is at a critical turning point with critical domestic and international implications. The reforms being carried out in China today not only provide guidance for the rest of the world, but they offer greater confidence that development and growth can be achieved progressively, whilst reducing the footprint on the planet.

Further Research

- Develop detailed industry sector roadmaps that include the broad economic impacts of government intervention and technological developments relating to energy intensity, production, employment, productivity and levels of competitiveness.
- Generate energy use matrices for different sectors and products to assess the costs and benefits of different policy measures, such as the impact of tightening standards, introducing rebate programs and price adjustments as well as technological and behavioural changes on cost, energy use and carbon emissions.
- There needs to be more detailed localised assessments of the effectiveness and level of implementation of the structural rebalancing, especially the current energy policies, in particular the role of local support and resistance for the concept of the low carbon economy. Undertaking a regional or city-based analysis of the implementation of a low carbon economy would provide important insights into this policy's social and economic impacts and relationship to the rebalancing program. The shape and form of current aggregated data on energy consumption at a sectoral level makes detailed analysis difficult to undertake at the national level. Moreover, very few studies to date have examined the social and economic role of labor, firm, finance and employment relations following climate-policy related structural adjustment. It is envisaged that such a study could be undertaken on a comparative basis to examine a range of geographically distinct locations.
- Examine the economic structural issues relating to trade and investment flows, especially in energy intensive industries. For instance, understanding the implications and practices of Chinese manufacturers either exporting products or shifting production to the developed world to determine energy and environmental practices would be beneficial. As such, a study determining the reach of China's low carbon economic policy, for example, are they spreading energy efficient and leading edge technologies, exports and investments to other developing economies? An extension of the existing project focus on motor vehicles and air conditioners could be undertaken.
- Improved understanding of the relationship between innovation and R&D and new product commercialisation is developing rapidly in China. Recent government funding programs, greater international collaboration and stronger private sector interest may be shifting the balance towards China's role as the leading generator of new innovation and intellectual property. The role of universities, private companies and venture capital continues to play a key role in the US in developing and commercialising leading edge technologies, but it would be useful to better understand how such investments and decisions are developing in China. China has embarked on a low carbon research and development funding program to support private and commercial spin-offs from its leading research centres, but it will still take some years before the innovative and entrepreneurial environment of the US can be matched in China. However, there is a need to better understand this process and assess its potential.
- Assess the resource risks for the development of new energy technologies, for instance the relationship between competing uses of resources and policies. The role of rare earth elements and the development of battery technologies, such as lithium ion cathodes or the relationship between natural gas and renewables under a carbon tax system could be examined for example.

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Appendix: Methods and Data

Methods for measuring structure and intensity

The measures used for the structure and intensity effects are derived as follows. Total energy use in period *t* is given by:

$$E_t = \sum_i y_{ti} \,.\, \varepsilon_{ti} = \sum_i (y_{0i} + \Delta y_{ti}) \,.\, (\varepsilon_{0i} + \Delta\varepsilon_{ti}), \qquad (1)$$

where Δy_{ti} and $\Delta\varepsilon_{ti}$ are the change in value-added in sector *i* (y_i) and in the energy intensity of sector *i* (ε_i) in period *t* relative to the base period (t_0).respectively. This implies:

$$\Delta E_t = \sum_i (y_{0i} \,.\, \varepsilon_{0i} + \Delta\varepsilon_{ti} \,.\, y_{0i} + \Delta y_{ti} \,.\, (\varepsilon_{0i} + \Delta\varepsilon_{ti}) - \sum_i y_{0i} \,.\, \varepsilon_{0i}$$

$$= \sum_i (\Delta\varepsilon_{ti} \,.\, y_{0i} + \Delta y_{ti} \,.\, \varepsilon_{0i} + \Delta y_{ti} \,.\Delta\varepsilon_{ti}) \qquad (2)$$

The first term in the summation represents the change in total energy use due to changes in energy intensity in the industry sectors, for opening levels of GDP in the sectors. The second term represents the change in energy use due to changes in GDP in individual sectors, for opening energy intensity levels within the sectors, and the third is that due to interaction effects between changes in GDP and in energy intensity at the industry level.

Let s_{ti} be the share of sector *i* in total GDP at time *t*, and Y_t be total GDP at *t*, so that:

$$\Delta y_{ti} = s_{ti} \,.\, Y_t - s_{0i} \,.\, Y_0 = (s_{0i} + \Delta s_{ti}) \,.\, (Y_0 + \Delta Y_t) - s_{0i} \,.\, Y_0 = s_{0i} \,.\, \Delta Y_t + \Delta s_{ti} \,.\, Y_t \,. \qquad (3)$$

Thus, substituting (3) into (2),

$$\Delta E = \sum_i \Delta\varepsilon_{ti} \,.\, y_{0i} + (s_{0i} \,.\, \Delta Y_t + \Delta s_{ti} \,.\, Y_t) \,.\, (\varepsilon_{0i} + \Delta\varepsilon_{ti})$$

$$= \sum_i \Delta\varepsilon_{ti} \,.\, y_{0i} + s_{0i} \,.\, \varepsilon_{0i} \,.\, \Delta Y_t + \Delta s_{ti} \,.\, \varepsilon_{0i} \,.\, Y_t + s_{0i} \,.\, \Delta Y_t \,.\, \Delta\varepsilon_{ti} + \Delta s_{ti} \,.\, \Delta\varepsilon_{ti} \,.\, Y_t$$

$$= \sum_i s_{0i} \,.\, \varepsilon_{0i} \,.\, \Delta Y_t + \Delta\varepsilon_{ti} \,.(y_{0i} + s_{0i} \,.\, \Delta Y_t) + \Delta s_{ti} \,.\varepsilon_{0i} \,.\, Y_t + \Delta s_{ti} \,.\, \Delta\varepsilon_{ti} \,.Y_t \qquad (4)$$

Given that $E_t = E_0 + \Delta E_t = \sum_i s_{0i} \,.\, \varepsilon_{0i} \,.Y_0 + \Delta E_t$

$$E_t = \sum_i s_{0i} \,.\, \varepsilon_{0i} \,.\, Y_t + \Delta\varepsilon_{ti} \,.(y_{0i} + s_{0i} \,.\, \Delta Y_t) + \Delta s_{ti} \,.\varepsilon_{0i} \,.\, Y_t + \Delta s_{ti} \,.\, \Delta\varepsilon_{ti} \,.\, Y_t \text{, and}$$

$$E_t/Y_t = 1/Y_t . \sum_i s_{0i} \,.\, \varepsilon_{0i} \,.\, Y_t + 1/Y_t . \sum_i \Delta\varepsilon_{ti} \,.(y_{0i} + s_{0i} \,.\, \Delta Y_t) + 1/Y_t . \sum_i \Delta s_{ti} \,.\varepsilon_{0i} \,.\, Y_t$$

$$+ 1/Y_t . \sum_i \Delta s_{ti} \,.\, \Delta\varepsilon_{ti} \,.Y_t$$

$$= E^* + \sum_i \Delta\varepsilon_{ti} .(y_{0i} + s_{0i} . \Delta Y_t)/Y_t + \Delta s_{ti} .\varepsilon_{0i} + \Delta s_{ti} . \Delta\varepsilon_{ti} \qquad (5)$$

where $1/ Y_t \sum_i s_{0i} . \varepsilon_{0i} . Y_t = \sum_i s_{0i} . \varepsilon_{0i} .Y_t = E^*$ is the level of energy use, for a given Y_t, that would occur if the shares and energy intensities were fixed, that is if the overall energy intensity were fixed.

Thus the last three components in (5) represent the intensity, composition and interactive effects respectively, in terms of contributions to changes in overall energy intensity. Here we follow the principle of 'jointly created and jointly distributed' (Ang & Zhang, 2000) and allocate the multiplicative effect equally between the composition and share effects. As a result we decompose the *change in total energy use* into two components:

- The intensity effect: $\sum_i \Delta\varepsilon_{ti} . y_{0i} + \Delta y_{ti} .\Delta\varepsilon_{ti}/2$ and
- The structure effect: $\sum_i \Delta y_{ti} . \varepsilon_{0i} + \Delta y_{ti} .\Delta\varepsilon_{ti}/2$.

Equivalently, we compose the change in total energy intensity into two components:

- The intensity effect: $\sum_i \Delta\varepsilon_{ti} .(y_{0i} + s_{0i} . \Delta Y_t)/Y_t + \Delta s_{ti} . \Delta\varepsilon_{ti}/2$ and
- The structure effect: $\sum_i \Delta s_{ti} .\varepsilon_{0i} + \Delta s_{ti} . \Delta\varepsilon_{ti}/2$.

Data Issues

The key requirements for an energy decomposition analysis by industry are real value added and energy consumption by industry. Most of the studies referred in the literature to date use the gross value of production as the output variable, because of the difficulties of obtaining data on value added by industry (for a review see Sheehan and Sun 2007). But value added, which excludes inputs to the production process, is much to be preferred as the output variable, as the energy embodied in inputs to production is not counted as energy consumption by the industry in question, and may change significantly over time as the structure of production changes. The Chinese national accounts data provide consistent real value-added series for six sectors (agriculture, industry, construction, transport, storage and post, wholesale and retail trade, and other tertiary industries) for the full 1980-2008 period, consistent with the revisions to the national accounts as a result of the First National Economic Census in 2004 (NBSC, 2005) but not yet consistent with the Second National Economic Census in 2009. But with over 70% of China's energy use taking place in industry (excluding construction but including mining) it is important to disaggregate this sector, and here problems arise.

Value-added data by detailed industry are available only from 1994, in current prices and for 'designated enterprises', the criteria for which changed in 1998. Prior to 1998, this description covered all enterprises with an independent accounting system which were owned or regulated at or above the township level, whereas from 1998 it covered all state-owned enterprises (SOEs) with an independent accounting system and all non-SOEs with an independent accounting system and annual sales revenue in excess of 5 million yuan (Holz and Lin, 2001). The independent accounting system test is common to both periods, so the critical change is from being owned or regulated at the township level or above before 1998 to being either an SOE or having sales over 5 million yuan after 1998. As Holz and Lin point out, the gross value of production of designated firms by the pre-1998 test amounted to over 90% of that overall all industry in 1980, but fell to only about 60% in 1997, prompting the change. While there seems to have been little impact of the change on this share in 1998, the effect of moving to a fixed monetary limit was to increase the coverage of 'designated enterprises' as both inflation and rapid growth eroded the impact of that limit. By 2004 this ratio had recovered to be over 90%, and a similar pattern is evident for value added.[87] This means that studies that use either gross value of production or value added for designated firms in relation to total energy use by industry may generate seriously misleading results. For the last three years (2007-09) the NBS has published the percentage change in current price value added by industry relative to the same month of the previous year (on both a single month and at year to that month basis). As there is no reference to 'designated enterprises', we take this to refer to each industry as a whole.

The methodology adopted to assemble real value added by detailed industry for 1994-2009 is as follows. The starting point is three data sources: the current price series on value added by industry for designated enterprises for 1994-2006; total industry value added for all enterprises from the national accounts for 1994-2006, together the implicit price index for this aggregate for 1994-2009; and gross industry output value (GIOV) data for all industries for 2004 and for designated enterprises in 2003 and 2005.[88] The relationship for individual industries between the output data for designated enterprises and for all enterprises in 2003-05 is used to gross up the value-added data for designated firms over 1994-2005 to create industry value-added estimates consistent with the national accounts total. For the last three years we apply the percentage change in the year to December (accumulated, and for 2009 so far only for November) to the industry estimates from the previous year, starting with 2007.

The question of the price index to be used to obtain real value added is also important. Whereas different industries will be subject to a range of different factors affecting both input and output prices for example, changes in raw materials or energy prices), the costs incurred in the value-adding process should mainly reflect common cost factors within China. For this reason we use the overall price deflator for industrial value added from the national accounts to convert value added for each industry into constant values.

Data on energy consumption by industry is available from the *China Statistical Yearbook for 1994-2007* while an aggregate figure for 2008 has also been published by NBS. This allows the series for energy consumption per unit of real value added to be constructed by industry for 1994-2007, with an aggregate figure only for 2008.

[87] Being data collected from a specific group of enterprises, it must be assumed that these data do not reflect the additional industrial output detected in the 2004 National Economic Census. As the denominator of this ratio incorporates the post-2004 adjustments, the value of the ratio in recent years will also reflect these adjustments to the aggregate data for industrial value added. The major part of the increase in value added detected in the 2004 Census was, however, in the services sector.

[88] GIOV for designated enterprises has not been published for 2004, so the average of 2003 and 2005 is used.