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China's ongoing energy efficiency drive: Origins, progress and prospects

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ABSTRACT

In 2004 China's government launched a vigorous programme to reverse the trend of rising national energy intensity and to reduce intensity by 20% over the period 2006–2010. The aim of this paper is to examine this programme in the context of nearly 30 years of measures to enhance energy efficiency in China, and thus to evaluate the likelihood that today's policies will yield improvements over a longer period. The country achieved a sustained decline of energy intensity in the period 1980–2001 but this trend was reversed in 2002. This reversal arose from a shift in the structure of the economy to more energy-intensive industries and from a decline in the rate of technical innovation. The measures taken since 2003 have been directed principally at energy-intensive industries, but have also addressed other sectors of the economy. Though the energy intensity target for the year 2010 may be achieved, greater efforts will be needed to address a number of constraints which include: the reluctance to use economic and financial instruments; the dependency of energy policy on industrial and social policies; the nature of political decision-making and of public administration; a shortage of skills; and social attitudes to energy.

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1. Introduction

Energy efficiency and energy saving are becoming increasingly important components of government policy around the world in response to a range of challenges including perceptions of resource scarcity, high energy prices, security of energy supply and environmental protection.

Among developing and transition nations, China is the country with the greatest and most visible set of challenges relating to the energy production and consumption. Indeed, it has long been recognised that the effective management of energy production and consumption should lie at the centre of any strategy for China's sustainable development (Smil, 1981, 2004; McElroy et al., 1998; Berrah et al., 2007). This is on account of the size of the economy and population, the rate of growth of its economy, its relatively high energy intensity, the large proportion of coal in the energy mix and the massive and growing impact on the environment, both local and global.

Energy conservation and energy efficiency became an important part of China's government policy from the early 1980s at a time when shortages of energy threatened the nation's economic development (Nakajima, 1982). Administrative measures were put in place in the 1980s which resulted in two decades of declining energy intensity. During the 1990s, the high priority assigned to energy efficiency was repeated in official documents (Ministry of Energy, 1992; State Planning Commission, 1995) and became a growing theme for international collaboration (World Bank, 1993; International Energy Agency, 1997).

A reversal in this long-term trend of declining energy intensity in China occurred in 2002 as a consequence of a spurt of economic growth. By 2004, the country was suffering from serious shortages of all major forms of energy. In response the government embarked on a programme of vigorous measures to halt this rise in energy intensity and to bring about a reduction of 20% from 2006 to 2010.

General agreement exists that an effective energy efficiency policy requires a combination of measures including regulatory instruments, financial incentives, information provision, and that the mix of measures needs to be adapted to the situations of each particular country (United Nations Economic Commission for Asia and the Pacific, 2004; United Nations Economic and Social Commission for Europe, 2005; Energy Charter Secretariat, 2007). Energy efficiency should not be restricted to just energy policy, but should become an integral part of most government policies including those for industry, taxation, transport, environment, and social security. Though regulations and pricing are crucial elements of energy efficiency policy, the underlying requirement for success is a change in attitudes and expectations throughout society. This requires education and information, and the encouragement of active participation on the part of all parts of society from individuals, to households, to large and small companies, industrial associations, civil society organisations, and officials at all levels of government (Thollander et al., 2007; Energy Charter Secretariat, 2007; Zografakis et al., 2008).

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Likewise, a consistent pattern is emerging of the types of obstacles which can slow down or prevent the implementation of energy efficiency policy, though typologies of these obstacles are highly variable (Weber, 1997; Science Policy Research Unit, 2000; United Nations Economic and Social Commission for Asia and the Pacific, 2004). Among the most easily identified obstacles are a lack of reliable information, a shortage of technical skills, weak economic incentives, a shortage of financing, and inadequate capacity within government. In addition to these easily measurable obstacles, a number of other factors exist which may be just as important. These include the systems of public administration, political failure on the part of government to follow rhetoric with action, poor leadership and management systems within enterprises, and an unwillingness or inability among individual citizens to change their behaviour or to recognise opportunities to maximise utility (United Nations Economic Commission for Europe, 2004; Sola and Xavier, 2007). Given the range of challenges and obstacles to implementing energy efficiency policy, it is essential for governments to focus their energies initially on sectors where the impact is likely to be greatest and using instruments which are most likely to be effective (Energy Charter Secretariat, 2007).

The aim of this paper is to examine China's current programme to reduce national energy intensity in the context of nearly 30 years of measures to enhance energy efficiency, and thus to evaluate the likelihood that today's policies will yield improvements over a sustained period in the light of the key instruments and obstacles identified above. The paper begins with a review of the period from 1980 to 2001 and explains how the country was able to achieve a sustained decline of energy intensity over this time interval. It then examines the range of causes of the increase in energy intensity from 2002 and shows how the government responded with a wide ranging package of measures to address the challenges of soaring energy demand. The paper concludes with an assessment of the performance of the energy efficiency programme to date and the outlook for the future.

2. Energy supply and demand to 2001

The nearly three decades of China's economic development since reform was launched in the late 1970s can be divided into two main phases from the perspective of energy consumption: the period to 2001 which was characterised by falling energy intensity, and the years since 2002 when this trend was reversed.

This section provides the background to the development of the energy sector in the first of these two periods, the 1980s and 1990s, and examines the reasons behind the sustained decline of energy intensity.

2.1. Trends in energy supply and demand

The period 1980–1996 was characterised by sustained high levels of economic growth in China, with only occasional interruptions. The average rate of increase of GDP was about 11% (National Bureau of Statistics, 2007a). Throughout most of this period economic growth was driven by the industrial sector, though the tertiary sector expanded greatly, and both grew at the expense of the primary sector (Naughton, 2007; Bosworth and Collins, 2007; National Bureau of Statistics, 2007a). This growth was accompanied by a gradual reform and liberalisation of the industrial sector and of the domestic commodity markets (Chiu and Lewis, 2006; Naughton, 2007). These measures also affected the energy sector, but to a lesser extent than most other industries (Andrews-Speed, 2004).

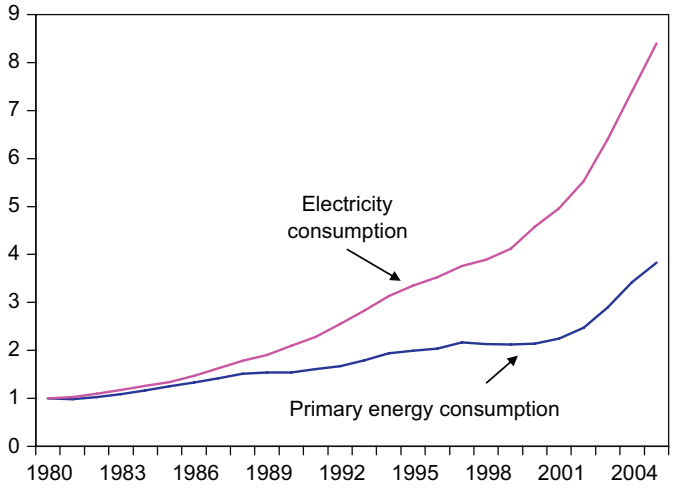

Fig. 1. Primary energy consumption and electricity consumption in China, 1980–2005, normalised to 1980 levels *Source*: Energy Information Administration (2008).

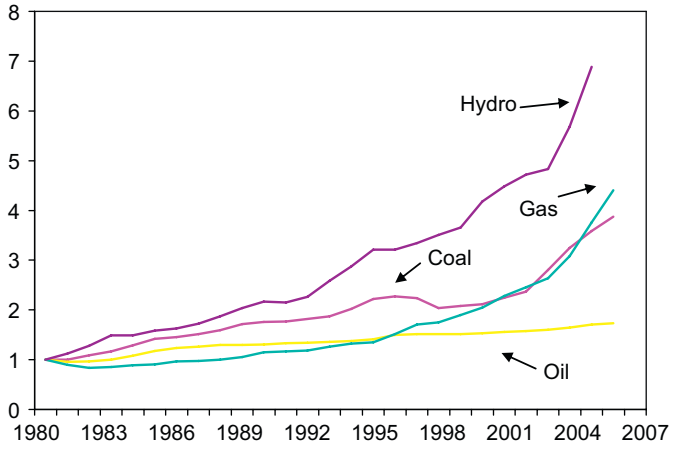

Fig. 2. Primary energy production in China, 1980–2007, for different types of energy, normalised to 1980 levels. *Source*: BP (2008) for oil gas and coal; Energy Information Administration (2007) for hydro-electricity (data to 2006 only).

As the economy grew, so did energy consumption, until the Asian crisis when demand flattened, at least according to official Chinese statistics (Fig. 1, Sinton and Fridley, 2000). The country's primary energy supply was and still is heavily dependent on coal. The proportion of coal in the energy mix appeared to decline from 75% of total primary commercial energy consumption in 1995 to 66% in 1999, but this decline may, in part, be a result of systematic statistical distortions related to false reporting of coal output at this time (Sinton, 2001). Throughout most of this period the proportion of oil in the energy mix increased to reach 23% in 2001 as its use in transport and petrochemicals grew. The role of natural gas and hydro-electricity remained small at about 2% and 6% respectively (BP, various years).

Throughout the 1980s and 1990s China was largely self-sufficient in primary energy supply. Domestic production of coal, hydro-electricity and natural gas continued to rise, aside from the apparent decline of coal output in the late 1990s (Fig. 2). The country has always been self-sufficient in coal, and since the late 1990s has become a significant net exporter. The story for oil has been quite different. Since the mid-1980s the oil industry has struggled to raise production at annual rates of just 1–3% per year,

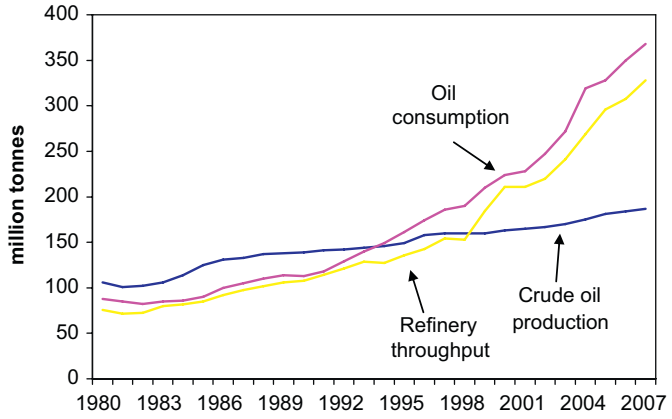

Fig. 3. Oil production and consumption in China, 1980–2007. Sources BP Statistical Review of World Energy, 2008.

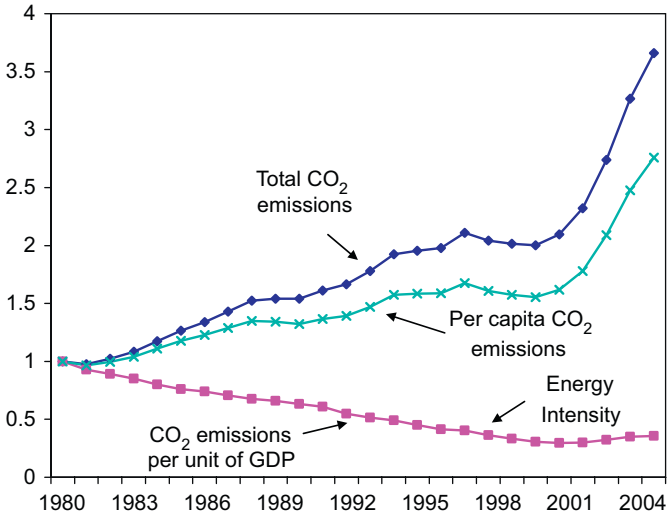

Fig. 4. Energy intensity and carbon dioxide emissions in China, 1980–2005, normalised to 1980 levels. *Source*: Energy Information Administration (2007).

meanwhile consumption has been rising at annual rates of between 5% and 8%. Since 1993 China has become a net importer of oil, and the import requirement has grown each year (Fig. 3). The construction of oil refinery capacity has continued at a great pace (Fig. 3) and so a large proportion of China's oil imports take the form of crude oil which is then refined in domestic plants.

This period also saw the rapid rise of the role of electricity in final energy consumption (Fig. 1), replacing the direct combustion of coal and oil, and the gradual introduction of nuclear power generation and modern renewable energy such as wind and solar power.

The most notable feature of the energy sector during this first 20 years of China's economic reform was the consistency with which energy intensity declined (Fig. 4). This decline occurred for all major forms of primary energy, but was most marked for coal (Hang and Tu, 2007). This was paralleled by a decline in carbon dioxide emissions per unit of GDP, although total carbon dioxide emissions and per capita emissions rose as the energy consumption grew (Fig. 4).

2.2. *Explaining the energy intensity decline in the 1980s and 1990s*

Three main sets of explanations may be invoked to explain a decline of energy intensity in a country: changes in the structure of the economy, improvements in the efficiency with which energy is supplied, and enhanced efficiency of energy use within certain sectors of the economy. In the case of China, the debate has been between structural shifts and efficiency improvements, though changes in fuel supply have also contributed to the decline of energy intensity.

Econometric analyses carried out in the last few years seem to have confirmed earlier results (Sinton et al., 1998), which suggested that the impact of structural change in China's economy on energy intensity has been less important than that of the energy efficiency improvements within industries (Fisher-Vanden et al., 2004). Though the early 1980s saw an expansion of the Tertiary sector, since the mid-1980s the proportion of secondary industry has grown at the expense of the primary sector. This structural shift may even have created an underlying long-term rise of energy intensity rather than any reduction (Ma and Stern, 2008).

Instead a consensus has emerged that the steady decline of energy intensity during the 1980s and 1990s can be mainly attributed to efficiency and productivity changes within industries, and that these gains were achieved through technological improvements, research and development, and innovation (Sinton et al., 1998; Fisher-Vanden et al., 2004; Liao et al., 2007; Sheehan and Sun, 2007; Ma and Stern, 2008). Since the mid-1990s, efficiency improvements have been particularly marked in energy-intensive industries such as metallurgy, cement, paper, textiles, oil and coal processing, and electrical power generation (Hu et al., 2005; Steenhof, 2006; Rosen and Houser, 2007; Liao et al., 2007; Lin et al., 2008).

Though these improvements have been marked, they have been highly variable across the country. In the case of steel plants, for example, a wide difference exists between those plants which have made substantial improvements and those which have made more modest efficiency gains. In general, efficiency improvements have been greatest in provinces with private sector steel makers, such as Hebei and Jiangsu, rather than those with large state-owned steel makers such as Hubei, Beijing, and Shanghai (Wei et al., 2007).

The overall level of energy efficiency and the extent of the gains made in the 1990s were also both highly variable. In general the more advanced eastern provinces of China were the most energy efficient. The Central provinces were less efficient but showed the greatest gains in the late 1990s as they went through the rapid industrial development. Western China had the lowest efficiency and showed the least improvement on account of its slow development (Hu and Wang, 2006).

Though efficiency gains within industries were the main drivers for the steady decline of energy intensity in the 1980s and 1990s, the changing mix of energy supply also made a contribution. Two trends were particularly important: the growing use of electricity in end use, especially in industry since at least 1980 (Steenhof, 2006; Fig. 1), and the reduction of the proportion of coal in the primary energy supply during the 1990s, as industries and households switched to other fuels, especially to oil products and to hydro-electricity (Han et al., 2007; Cai and Jiang, 2008).

The sustained improvement of energy efficiency within different sectors of the economy may be attributed to systematic policy measures launched in the 1980s to enhance energy efficiency and to the gradual marketization of the economy, especially since 1993. In the early 1980s, the government established a suite of policy instruments to encourage energy saving. Industry and most commodities were still largely subject to government planning and the government could use administrative instruments such as quotas and targets to great effect. Thus, quotas for energy consumption could be set for industries

and for individual plants, and the cost of energy which exceeded the quota was two to three times the basic price. The government established energy conservation technology centres throughout the country to provide information and training, and low interest loans and tax credits were available for investment in energy conservation. As a result, the level of investment in energy conservation rose rapidly from 1981 to 1995 (World Bank, 1993; Sinton et al., 1998; Lin, 2007; Sheehan and Sun, 2007).

Over the same period, two parallel trends were occurring in the economy. Firstly, energy prices were rising, for all fuels. The 1990s saw the government taking several steps to adjust the mechanisms by which energy prices were set. Coal prices were liberalised to a great extent, producer and consumer prices for electricity were raised, and by the end of the 1990s systems were put in place to adjust oil prices in line with international markets (Andrews-Speed, 2004). Secondly, progressively larger sections of the economy were becoming subject to market forces, especially since 1993, as the private sector grew, as the state sector was commercialised and as prices for most commodities were liberalised (Green and Liu, 2005; Naughton, 2007). The combination of higher prices, market forces and more diversified ownership of industry provided the ideal environment for innovation and for investment in research and development relating to energy efficiency. In this respect, foreign enterprises and other private sector players responded better than state-owned enterprises (Fisher-Vanden et al., 2004; Watanabe and Tanaka, 2007; Sheehan and Sun, 2007).

The very success of the energy efficiency policy combined with the increasing degree of marketization of the economy led to its demise. The 1990s saw the almost complete disappearance of planning as a direct tool of managing the economy. The autonomy of enterprises and local governments continued to grow. As a result the traditional administrative instruments were rendered largely ineffective (Andrews-Speed, 2004). By the late 1990s China's energy intensity had fallen to nearly one-third of that in 1980 and the country had a surplus of energy supply. The need for investment in energy efficiency appeared to have declined, and as a result, the level of government investment and effort in this field declined dramatically despite the introduction of an Energy Conservation Law in 1997 (Sinton and Fridley, 2000; Lin, 2007; Berrah et al., 2007).

3. Energy demand since 2002

This favourable downward trend in energy intensity was reversed in the year 2002. This section describes the recent and likely future trends in China's energy demand and identifies the factors which underlie the enhanced level of energy intensity.

3.1. Recent trends in energy demand

The years 2002–2005 were marked by a boom in economic growth and a surge in the output of heavy industry (Naughton, 2007). The national gains in energy efficiency made during the 1980s and 1990s were reversed from 2002. Energy intensity rose, the production and consumption of all forms of energy accelerated, oil imports soared, and levels of emissions of both carbon and other pollutants increased (Figs. 1–4).

As in the earlier period, three sets of factors can be identified as driving the trend in energy intensity. First, an expansion of the role of secondary industry clearly took place after a decline in the late 1990s, and this was focused on energy-intensive industries (Liu and Zhu, 2006; Rosen and Houser, 2007; Liao et al., 2007; Ma and Stern, 2008; Lin et al., 2008). The proportional increases in energy intensity were greater for coal and for electricity, which are the fuels of industry, than for oil, the fuel of transport (Hang and Tu, 2007). Total investment in fixed assets jumped from 36% to 47% of GDP over the period 2002–2005 (Liao et al., 2007). The output of key energy-intensive products rose sharply after the year 2000 (Fig. 5a), and China became firmly established as the world's largest producer of steel (35% of world output in 2006), cement (48% of world output), flat glass (49% of world output), and aluminium (28% of world output; Rosen and Houser, 2007). Surplus output could be exported and thus China's exports of these energy-intensive products soared (Fig. 5b; Yang and Zhang, 2007). The production of other products also grew

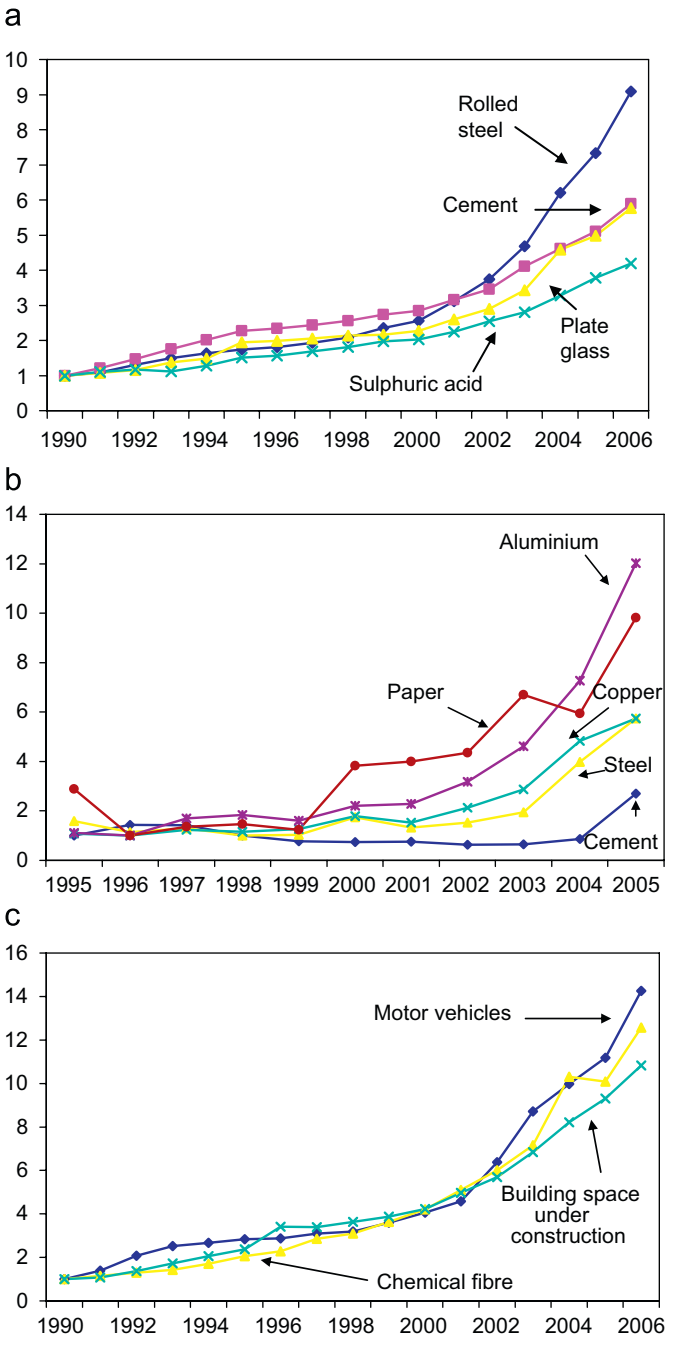

Fig. 5. (a) Output of selected energy-intensive industrial products, 1990–2006, normalised to 1990. *Source*: National Bureau of Statistics (2007a). (b) Exports of selected energy-intensive industrial products, 1995–2005, normalised to 1995 *Source*: National Bureau of Statistics (2007b). (c) Output of selected energy-intensive end-products, 1990–2005, normalised to 1990 *Source*: National Bureau of Statistics (2007a).

markedly during this period, for example building space, motor vehicles and chemical fibre (Fig. 5c).

At the same time as these industrial developments were pushing energy intensity upwards, technological advances were appearing to be having less impact in the other direction. Overall, at a national scale, the early years of the century were characterised by a slow down or even reversal in the rate of energy-related technological improvements, and such efficiency gains as there were failed to offset the impact of the structural shift (Ma and Stern, 2008; Lin et al., 2008). The overall level of investment in energy efficiency, as a proportion of total investment in energy, remained lower than at any time during the period 1981–1995 (Lin, 2007).

The third and final key factor underpinning the increase in energy intensity was the increase in proportion of coal in the energy mix at the expense of oil and hydro-electricity (Han et al., 2007).

3.2. Current and future energy demand

China's total energy consumption is now fast approaching that of the USA, the largest energy consumer in the world (Fig. 6a). Its energy intensity is also one of the highest in the world, when the GDP is measured at market exchange rates (Fig. 6b). However, a more benign view of China's energy demand is revealed by examining the demand on a *per capita* basis (Fig. 6c) and the energy intensity on a purchasing power parity basis (Fig. 6d). Though the *per capita* demand shows that China's people are not high energy consumers as individuals, this chart suggest that China's total energy demand has plenty of scope for rising in a sustained manner for many years as the economy grows and living standards rise.

Forecasts of energy demand in China have generally been proven to be rather inaccurate. To a great extent this is because the government has retained the power to constrain or stimulate growth in the economy, and such decisions appear to outsiders to come quite suddenly. But never have the forecasters been so utterly wrong-footed as they were by the surge in energy demand seen in the first few years of the twenty-first century (Shealy and Dorian, 2007). More recent forecasts have tried to make amends for these misjudgements. Over the period 2003–2007 published forecasts have tended to produce rates of growth of energy which become progressively higher, especially for the period to the year 2020 (Development Research Center, 2004; Chen, 2006; Sheehan and Sun, 2007; International Energy Agency, 2004, 2007; Energy Information Administration, 2007). Most notable is the change of the forecast's made by the International Energy Agency from a

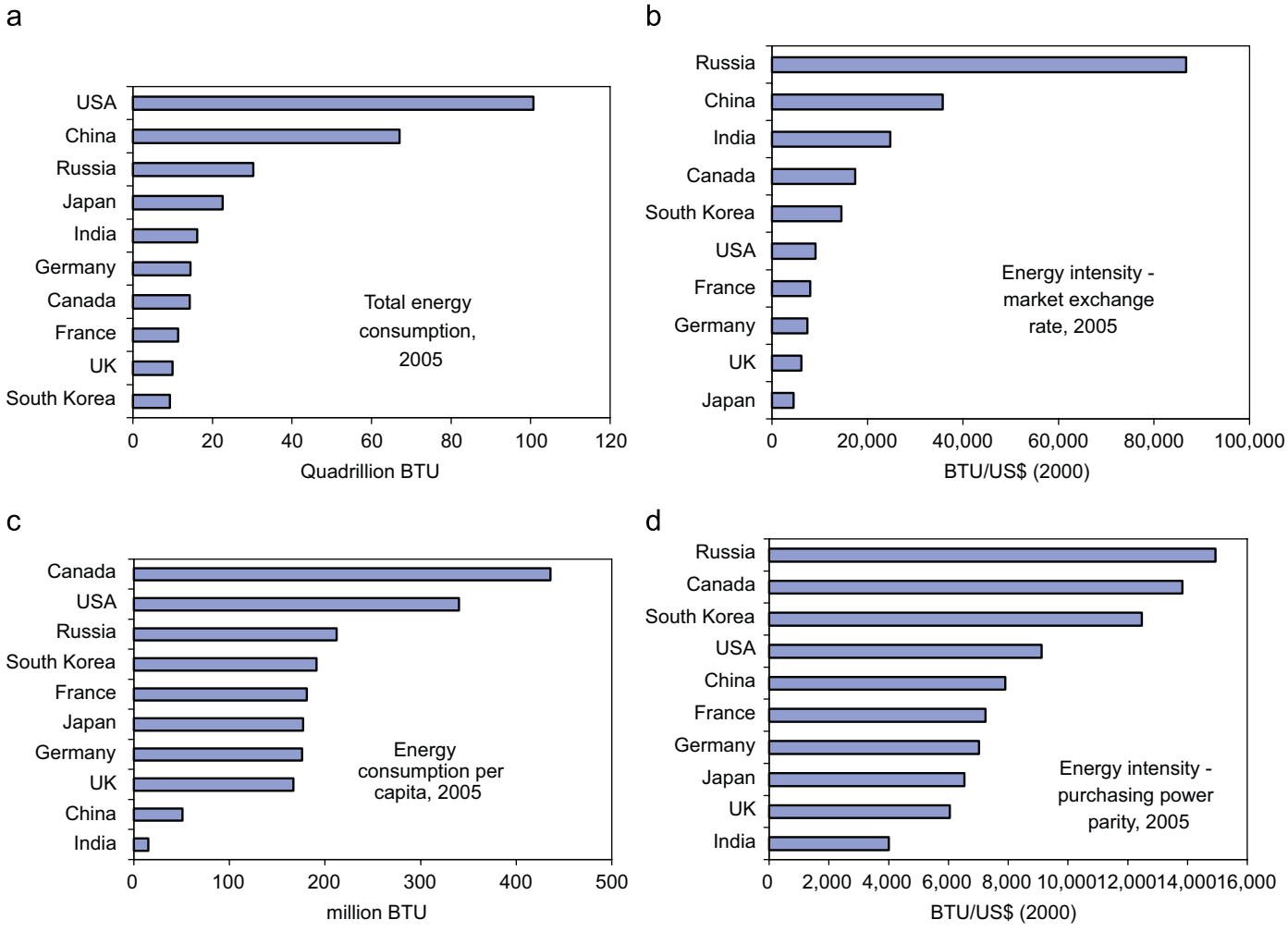

Fig. 6. (a) Total energy consumption for the top ten energy consuming nations in the world in 2005, quadrillion British Thermal Units. (b) Energy intensity for the top ten energy consuming nations in the world in 2005, at market exchange rates, British Thermal Units per US$ (year 2000). (c) Energy consumption per capita for the top ten energy consuming nations in the world in 2005, million British Thermal Units. (d) Energy intensity for the top ten energy consuming nations in the world in 2005, at purchasing power parity, British Thermal Units per US$ (year 2000) *Source*: Energy Information Administration (2007).

3.4% rate of growth of demand to 2020 made in 2004 to a rate of 4.6–5.1% for the period 2005–2015 made in 2007. These forecasts compare to a mean rate of growth of demand of 5.6% over the period 1980–2006, and 9.8% from 2000 to 2006.

Nearly all published forecasts imply that the period 2002–2005 was a freak event and foresee an imminent decline in the rate of growth of China's energy demand. Sheehan and Sun are much less optimistic about China's ability to change its energy systems and they project demand rising 5.9–7.9% over the period 2005–2015, and 4.6–6.4% for the period 2005–2030 (Sheehan and Sun, 2007). Though the two percent difference between the projections of the IEA and of Sheehan and Sun appears to be small, over a 25 year period the impact is substantial. An average rate of growth of 3% over 25 years leads to a doubling of energy consumption; a 5% rate, leads to a trebling. Though their approach is less quantitative, Shealy and Dorian also challenge the prevailing forecasts and suggest rates of growth of coal consumption for the period to 2025 of 4.5–8.5% (Shealy and Dorian, 2007). They argue that their analysis is based on a more realistic understanding of the constraints on the country's energy system and on the economy.

3.3. Factors underlying China's energy demand

A very wide range factors determine the scale and nature of a country's energy consumption and, at the same time, constrain the ability of the government to change the pattern of consumption in a short period. Such is the scale and nature of China's economy, that these constraints are likely to be particularly powerful.

It can be argued that China's stage of economic development is such that the demand for energy will necessarily keep rising at rates broadly similar to those of the 1990s and early 2000s, and that a substantial reduction in the rate of increase is very unlikely to occur. Progressive industrialisation and urbanisation, combined with the continuing introduction of market forces and integration with the world economy, will continue to keep China on a course of rapidly rising energy demand. This pattern of rising demand will be seen for all the major fuels such as coal, electricity and oil, as well as natural gas in the future (Steenhof, 2006; Gong, 2007; Sheehan and Sun, 2007; Shealy and Dorian, 2007; IEA, 2007; EIA, 2007).

Underpinning this trend of sustained growth of energy demand has been the continuing dominant role in the economy played by industry (He et al., 2006). Though this would appear to have been a key component of the government's long-term economic strategy, investment booms in China have tended to lead to a disproportionate expansion of capital- and energy-intensive industries. The reasons for this extend deep into the national political and economic structures and systems (Rosen and Houser, 2007).

The performance assessment for local governments has continued to be based on economic growth. This has led to local government officials focusing their efforts almost solely on GDP statistics, at the expense of other concerns such as social welfare, resource management, technological and energy efficiency, and the environment. Competition between localities for investment and for sales revenue from key enterprises has exacerbated this phenomenon. Local governments have the power to provide enterprises with land for construction at a low cost. At times of rising prices these enterprises can be very profitable. Most state-owned enterprises have not had to pay dividends, and any bank loans they have are at relatively low real interest rates. Consequently they have large quantities of funds for investment. If their over-investment produces more product than the domestic market can absorb, these surpluses can be exported, partly on account of the low exchange rate.

Specific phenomena may be identified in each sector of the economy which have helped to keep energy intensity at it high level and which could continue to constrain efforts to enhance energy efficiency. The most important of these are the energy-intensive industries, electricity, construction, and transport.

China's energy-intensive industries continue to have a disproportionately high number of small-scale plants which are both inefficient users of energy and are highly polluting. In the case of cement, more than 5000 small plants were operating in the year 2005. The top ten producing enterprises accounted for just 13% of national cement production, and energy efficient rotary-type kilns accounted for only 40% of production. The market power of the small plants is enhanced by trade and transport barriers which reduce inter-provincial trade in cement (Urandaline, 2006). This problem of scale and efficiency affects several other energy-intensive industries such as steel, non-ferrous metals, glass, paper and chemicals. Indeed the number of enterprises in these different industries increased over the period 2002–2006 by factors of between 30% and 100%, as businesses sought to take advantage of the high prices (Rosen and Houser, 2007).

The electrical power industry also suffers from having too few large-scale and highly efficient plants (Mi, 2006; Zhang, 2007). This inefficiency in the production of electricity is exacerbated by a number of other factors, for example: the high proportion of coal in power generation; the low proportion of coal for power sector which is washed; the level of technologies used in thermal power plants; the low level of coal prices for electricity generation; the low proportion of hydro-electricity, renewables and co-generation; the inappropriate systems for despatching generators which do not necessarily favour the most efficient; and the high level of energy losses in transmission and distribution grids (Mi, 2006; Zhang, 2006, 2007; Yang, 2007).

At the consumption end of the power industry China started to gradually implement a number of demand-side management (DSM) instruments in selected cities during the 1990s. In addition to conventional energy efficiency measures, a number of steps were introduced to reduce and to shift the daily peak load. These achieved some success but not as much as would have been hoped (Hu et al., 2005). Like many developing countries, China has consistently maintained a low level of end-user pricing for most categories of electricity consumer, especially for industry and households (Andrews-Speed, 2004). Though this policy may have some justification from the perspective of social equity, it fails to provide incentives to save energy (Li, 2007). As the proportion of electricity in energy end-use increases, the importance of enhancing the efficiency of use of electricity rises. The government's continued reluctance to pass the full costs of supply on to the consumers of electrical power has long been a major factor constraining the country's ability to make energy savings (Hu et al, 2005). Appliance standards also have an important role to play, for both household and industrial users, and China has been slow to raise these standards and to provide incentives to make and to buy appliances with high levels of energy efficiency (Kang et al. 2006; Zhang, 2007).

Construction is another example of an industry in which standards have fallen far behind those required by the national regulations and in which the cost of addressing its deficiencies will be very large. Though China has national standards for the construction of buildings, only a very small proportion of new buldings meet these standards: possibly as low as 2% of all buildings in the year 2000 and just 5% of new buildings a few years later (Yao et al., 2005; Berrah et al, 2007).

The sources of the failure in the construction industry are diverse. Many plants which make the construction materials use

small-scale and outdated technologies which produce sub-standard products (Xiong, 2007), particularly in areas with low levels of economic development outside urban centres (Yao et al., 2005). The cost of upgrading these plants is high, and incentives to do so are absent. Likewise the barriers to commercialising new energy efficient technologies are high. Construction companies lack guidelines and training for energy efficient building design and construction, and even when the design is appropriate, there can be a mismatch between design and construction. In addition to the designers and builders, the buyers of buildings also lack clear guidance in the form of labelling of both buildings and individual appliances within the building (Yao et al., 2005; Liang et al., 2007). Though the current energy use per square meter in Chinese buildings is still much lower than in OECD countries (Yang and Jiang, 2007), this is almost certain to change as rising social expectations result in a desire for higher indoor temperatures in winter and lower temperatures in summer (Yoshino et al., 2006; Kang, 2007).

At the heart of the problem of construction standards has been the unwillingness or inability of local governments to draw up detailed regulations to suit local conditions and to enforce the national regulations through inspections and through penalties for infringement (Yao et al., 2005). Indeed, the very reverse has been true. Local governments have encouraged the rapid construction of government buildings at tax-payers' expense and of industrial plant and office blocks on land made available at low cost. Such behaviour reflects, in part, the economic competition between regions, but it may also be a result of the lack of accountability of local governments to their populations. This serious deficiency is exacerbated by the wasteful construction of buildings for government departments, for state enterprises and for public use which are excessively large and grandiose, and often under-used.[1]

Transport is the final key sector which will have a substantial impact on future energy demand and on future energy import requirements. At present and in the near term transport will rely mainly on oil products, and the use of oil in China will become progressively restricted to transport and petrochemicals as industry and households continue to switch to other fuels. Whereas the rate of increase in demand for coal may be declining, the country's demand for oil appears to be in a phase of acceleration, at least in the transport sector (Gong, 2007; Shealy and Dorian, 2007; Rosen and Houser, 2007). A rapid growth of road vehicle numbers is unavoidable, and demand for oil for road vehicles and for the whole transport sector may average as high as 4–5% over the period to 2030. Over this period the proportion of oil demand accounted for by the transport sector is forecast to rise from 35% to 55% (IEA, 2007). In addition to conventional road vehicles, there are millions of agricultural vehicles. During the period 1995–2002 between two and three million of these inefficient, polluting but cheap vehicles were made each year. In the year 2000, for example, they accounted for 20–25% of total national diesel consumption (Sperling et al., 2005).

Within the transport sector, great potential exists to reduce the rate of increase of demand for oil and for dramatically changing the shape of the demand curve (He et al., 2005; Walsh, 2007). Though the government is taking steps raise manufacturing standards for vehicles and to develop and introduce new fuels and engine technologies, several factors have restricted the country's ability to constrain demand for oil in the transport sector. First, car manufacturing has long been seen as an industry which should be championed, both at national and local levels (Nolan, 2001). Second, as partly as a consequence of this, private car ownership by the growing affluent middle class has been encouraged. Third, and as a consequence of the first two factors, most cities have been slow to invest in modern public transport systems. Finally, the government has been wary of raising domestic prices for oil products in line with international prices, in order to protect the agricultural sector and other parties. For example, the desire to protect taxi drivers has been a significant factor in holding down prices. After a price rise announced in November 2007, Beijing city increased the level of subsidies for taxi drivers.[2]

4. The new approach from 2003

By 2001, the time of energy surpluses in China had come to an end. Fuel shortages and blackouts had become widespread by the end of 2002, and were a serious threat to the economy (Kong, 2005). These domestic vulnerabilities were compounded by the international factors. Conflict and instability in the Middle East were seen by China as real threats to its soaring oil import requirements. The September 11 attacks in the United States and the subsequent American strategic redeployment in Central Asia and the Middle East required a revaluation of China's strategic situation in these regions. Further, a high degree of consensus over the importance of global warming was being reached just as the level of emissions from China was accelerating.

Within China, a political transition was underway. From the 16th Party Congress in November 2002 to the formal appointment of the new government in March 2003, Hu Jintao and Wen Jiabao began taking over the reigns of power (Li, 2003). The challenges they faced combined with their vision for the country's development, their education and background, led to a new set of policy priorities. Energy was now high on the agenda of central government and they took immediate steps to increase the capacity and effectiveness of government in the energy sector and to develop new approach energy policy priorities.

4.1. New agencies

Two key priorities for the new government were to regain and centralise control over the energy sector and to provide for more coherent policy making. Since the abolition of the Ministry of Energy in 1993, responsibility for managing the energy sector had been split between a number of government agencies. This lack of a central energy agency seriously undermined the government's ability to formulate and implement energy policy (Andrews-Speed, 2004). As a first step to rectifying this deficiency the Energy Bureau was created within the National Development and Reform Commission (NDRC) in March 2003. This brought together many, but not all, of the energy functions which had been scattered across the previous State Development Planning Commission and State Economic and Trade Commission. The functions of the Energy Bureau included formulating policy and drawing up plans for sector reform, as well as routine oversight of the country's energy sector (Downs, 2006).

It soon became clear that this small bureau with a staff of less than thirty could not possibly fulfil its mandate. Two years later, in 2005, the government set up an Energy Leading Group within the State Council. This comprised the Prime Minister, two Vice Premiers, and thirteen senior government officials of Ministerial rank, drawn from the major relevant institutions. Their role was to

[1] 'China's wasteful construction high in the world', Chinese Business Gazette European Edition, 2 November 2007, p. A12.

[2] 'Beijing increases subsidy to taxi drivers following fuel price hike', Xinhua News Agency, Beijing, 11 November 2007.

set strategic directions and to improve policy coordination. They were supported by another new agency, the State Energy Office, which was staffed by government officials and technical specialists. This Office appeared to have relieved the Energy Bureau of some of its policy formulation role (Downs, 2006; Rosen and Houser, 2007).

March 2008 saw a new government installed and new expectations for the creation of a Ministry of Energy. Despite a wide ranging restructuring of government agencies and the amalgamation of a number of ministries into 'super-ministries' (Zheng and Wang, 2008), the adjustment to the energy agencies was not dramatic. A National Energy Commission was created at State Council level, taking the place of the Energy Leading Group. Within the NDRC, the Energy Bureau was elevated to become the National Energy Agency, absorbing the short-lived State Energy Office and reporting to the National Energy Commission.[3]

4.2. New policy priorities

During 2004, government agencies and think-tanks across China were engaged in a re-evaluation of China's energy policy. The most authoritative report to be published was that of the Development Research Centre of the State Council. This report identified the following main priorities for China's future energy policy (Development Research Center, 2004):

- Placing greater emphasis on energy conservation and energy efficiency, especially in industry.
- Integrating environmental priorities into energy policy.
- Maintaining domestic primary energy resources as the main source of energy supply, but improving the management of these resources.
- Enhancing the role of the market within the domestic energy sector.
- Increasing the use of hydro-electricity, renewables, nuclear energy and natural gas, in order that reliance on coal may be reduced.
- Developing alternative transport fuels.
- Constructing emergency oil storage.

At the same time the NDRC issued their ''Medium and Long Term Energy Conservation Plan'', which not only demonstrated that energy efficiency and energy conservation did indeed lie at the heart of China's new energy policy but also laid out specific targets and objectives and identified the key steps to be taken (National Development and Reform Commission, 2004).

These priorities were further elaborated in the Five-Year Plan for the period 2006–2010 (National Development and Reform Commission, 2007a) and work has been underway since 2006 to draft an Energy Law which will encapsulate the key aims and approaches to China's new energy policy.[4] The importance of energy conservation in economic development was emphasized in both the 2007 Economic and Social Development Plan (National People's Congress, 2007) and the Report of the Seventeenth Congress of the Chinese Communist Party.[5]

[3] 'China sets up Energy Commission, also keeps Bureau', Reuters, Beijing, 11 March 2008; 'China launches sweeping institutional restructuring of government', Xinhua News Agency, 11 March 2008.

[4] A draft of the Energy Law was issued in November 2007 for public comments, which were submitted by February 2008. The revised draft was then sent out to Ministries and Provincial governments for their comments. As of November 2008 no final version of the Law has been issued or approved.

[5] 'Chinese agency urges prominence to energy conservation in industrialisation', Xinhua News Agency, Beijing, 3 December 2007.

The over-riding goal of the Energy Conservation Plan was stated to be to reduce energy intensity by 20% between 2006 and 2010. Subsequent documents have set targets for each province and for individual energy-intensive industries as well providing proposals for technological, process or management improvements needed to achieve these targets. A revised version of the 1997 Energy Conservation Law was approved in October 2007. These measures have been supplemented by a national plan to address the challenges posed by climate change, issued in May 2007 in response to the growing international criticism of China's rising levels of greenhouse gas emissions (National Development and Reform Commission, 2007b). Finally, all the key ideas relating to energy policy developed over the previous few years were encapsulated in a White Paper published in December 2007 (State Council, 2007a).

These actions and announcements demonstrate clearly that the government was seeking a new strategic direction for the energy sector. Security of energy supply remains the key concern, but substantially more emphasis is being placed on energy conservation and energy efficiency than before, and on environmental priorities. For the first time energy conservation can be said to lie at the heart of China's energy policy (Shi, 2006; Downs, 2006; Rosen and Houser, 2007; Yang, 2007; Meidan et al., in press).

5. Implementing the new policies

Since 2004 the government has continued to launch a wide variety of policy measures as part of the implementation of the Energy Conservation Plan and in order to attain the specified reduction in energy intensity. This section reviews a number of the most important of these measures under the following five headings: key strategic measures; industry; buildings, transport and public awareness; energy pricing; and targets for local governments.

5.1. Key strategic measures

The over-riding goal of the 2004 Medium and Long-Term Energy Conservation Plan was to reduce energy intensity by 20% between 2005 and 2010 an annual average of 3.6% per year, and to continue this decline at the same rate until 2020. This Energy Conservation Plan and subsequent documents have set targets for energy consumption per unit of output for the years 2010 and 2020 for individual energy-intensive industries such as electrical power generation, steel, non-ferrous metals, oil refining, petrochemicals, chemicals, cement and plate glass, as well providing proposals for technological, process or management improvements needed to achieve these targets. By 2010, standards for major energy using appliances are to be raised to international levels, and the systems for policy, regulation and technical support for energy conservation are to be dramatically improved.

The Energy Conservation Plan identified a number of projects which should yield significant savings in the short and medium term, such as retrofitting industrial boilers, district co-generation, and oil substitution in certain sectors. Aside from the industrial sector, the plan also identified the need to formulate a more coherent approach to transport policy and to enforce standards in the construction industry. Many of the same targets objectives and policies appear both in the Five-Year Plan for Energy Development and in the China National Climate Change Program, both published in 2007.

Included within the Energy Conservation Plan is the recognition that its objectives are unlikely to be achieved unless changes took place in the structure of the economy, and that a range of

economic incentives would be needed to encourage energy efficient behaviour. Whilst the Medium and Long-Term Energy Conservation Plan has no formal legal status, it called for the revision of the existing Energy Conservation Law passed in 1997 but which has had little impact, and for the formulation of other new laws, regulations and standards.

The revised Energy Conservation Law was issued on 28th October 2007, for implementation on 1st April 2008. This revised law has three key features. First, it codifies the major elements of the Medium and Long-Term Energy Conservation Plan. Second, in doing so it has a much wider scope than the original Energy Conservation Law which was directed principally at industry. Thirdly, and possibly most importantly, it places great emphasis on the behaviour and performance of the government itself. The Law places an obligation on public institutions to put in place systems to manage energy more effectively and thus to set an example to the rest of the country. It goes further to call for the establishment of a system of assessment for local governments and for government officials which takes into account their contributions to energy conservation. Finally, the number of articles in the law relating to legal liability and penalties has risen up from seven to nineteen and the penalties are tougher than in the original law.

These key policy and legal documents have been backed up by a significant increase in financial support. Investment in energy efficiency by the central government is set to rise to RMB Yuan 21.3 billion in 2007, which is thirteen times the level in 2006,[6] and a massive increase from the RMB Yuan 1 billion per year of the early 2000s (Lin, 2007). Figures for the total investment in energy efficiency are not available. In an effort to cool the rate of investment in fixed assets, the government raised one-year lending rates five times in 2007 and required banks to hold more reserves.[7]

5.2. Industry

Industry remains the key focus of energy conservation efforts in China, for this is where substantial gains can be made in both the short and the long term. Of greatest importance is the program for one thousand enterprises. These companies together account for about one-third of the total national consumption of energy and nearly 50% of industrial energy demand, and the aim is to save 100 million tonnes of coal equivalent of coal equivalent by 2010.

The details of the programme for one thousand enterprises were announced in April 2006 (National Development and Reform Commission, 2006). A total of 1008 enterprises were identified. They were charged with setting up management groups, establishing targets for all units within the enterprise, establishing procedures for energy audits, drawing up energy saving plans, investing in energy saving technologies, and introducing internal incentives to save energy. The programme allocates specific roles to different government departments. Local governments are to monitor, guide and supervise the performance of these enterprises, the State Statistical Bureau are to collect and publish information on their website, and the State-owned Assets Supervision and Administration Commission are to use energy saving as a measure of enterprise performance. Industry associations are also obliged to participate actively in the programme.

A potentially crucial set of instruments are a range of financial and fiscal policies such as providing income tax deductions for enterprises making energy saving products or reductions of VAT on specified energy saving technologies, equipment or products. To date, little progress seems to have been made in implementing these particular proposals (Chandler and Gwin, 2008). The major exception has been the repeated increases of export taxes and decreases in export tax rebates since 2004, directed at reducing the level of exports of energy-intensive products.[8]

The programme documents also provide for a range of supporting measures to be taken, for example:

- Policy support for upgrading existing facilities to save energy, and support financing and showcasing key projects.
- As yet unspecified systems to encourage widespread adoption of energy saving technologies.
- Penalties for enterprises which do not report the required information, which falsify information or which fail to establish the required internal management systems.
- Enhanced coordination between government departments.

Implementation of the 1000 Enterprise Programme requires agreements to be drawn up between the SOEs and the relevant levels of government. For the largest enterprises, owned at central government level, the agreements should be with the NDRC and, where relevant, the provincial government. Lower levels of SOE were to reach agreements with their respective levels of government (State Council, 2006; Wang, 2007). In Shandong, for example, the provincial government drew up a complex formal assessment system for 103 energy intensive companies (Shandong Provincial Government, 2006a, b). Special training programs were established to train the officials and managers involved in the implementation (Wang, 2007). The central government then drew on the ideas developed by the provincial government of Shandong and in November 2007 issued their own scheme for assessing the performance of the companies in the top-1000 enterprise programme (State Council, 2007b).

In addition to this 1000-Enterprise program, the government has drawn up a range of measures to address the challenges posed by the energy-intensive industries. These include raising energy prices, establishing voluntary agreements, closing small and outdated plants, and a number of specific measure in the power sector.

The central government has ordered local governments to charge higher electricity prices for energy-intensive industries, especially metallurgy and cement. The extra revenues raised are to be passed by the grid companies to local finance departments to support economic restructuring and energy conservation and pollution abatement.[9]

The Cleaner Production Promotion Law of 2002 encourages enterprises to reach voluntary agreements with local governments, to further improve their energy and environmental performance once they have reached national and local standards. For example, in Shandong Province two steel companies which signed agreements in 2003 achieved their voluntary three-year targets by late 2006 (Hu, 2007).

The greatest effort has been expended on closing down old, small-scale and inefficient plants, most notably in the power and steel industries. In the power sector, the government aims to decommission 50 GW coal of coal-fired capacity and up to 10 GW

[6] 'China earmarks 1.33 bn dollars for energy efficiency, discharge reduction', Xinhua News Agency, Beijing, 27 July 2007.

[7] 'China's fixed assets investment up 25.7% in first nine months', Xinhua News Agency, Beijing, 25 October 2007.

[8] 'Despite protests at home, China will adjust export tax rebate', Xinhua News Agency, Beijing, 24 July 2006.

[9] "NDRC calls for more effort in implementing differential electricity price policy", Interfax China Energy Weekly, VI, Issue 37, 11–17 October 2007, p. 9.

of oil-fired capacity during the period 2006–2010.[10] By July 2008, 26 GW of coal-fired capacity had been closed.[11] At the same time, the government has lowered the tariffs for power despatched from plants with capacities of less than 50 MW as well as from some plants in the size range 100–200 MW.

In addition to adjusting the efficiency and cleanliness of national generating capacity through construction and closure, the government has also taken steps to adjust the system for the dispatch of power plants. In August 2007, a new trial method for dispatch was announced (National Development and Reform Commission, 2007c), which set out the following order for dispatch:

1. Renewable energy
2. Nuclear power
3. Coal-fired co-generation units and those using waste heat
4. Natural gas and gasified coal units
5. Conventional coal-fired units
6. Oil-fired plants

For thermal plants within the same category, the order of dispatch should be on the basis, first, of energy consumption and, second, of pollution levels. Trials were started in late 2007 in five provinces, Henan, Jiangsu, Guangdong, Sichuan and Guizhou.

In the iron and steel sector, ten local governments in major steel producing areas have agreed to close small rolling mills, blast furnaces, converters and electric furnaces below a certain capacity, and to set new lower limits for the capacity of new plants. The aggregate plan involves closing 30 million tonnes of iron production capacity and 35 million tonnes of steel capacity in 2007, and a total of 100 and 55 million tonnes, respectively, by 2010.[12] By the end of 2007, 46 million tonnes of iron smelting capacity and 37 million tonnes of steel plants had been closed.[13] The government is also encouraging the consolidation of the steel industry so that the top ten companies account for 50% of production by 2010, compared with a very low figure of 27% at the end of 2006 (Urandaline, 2007).

The same tactics are being followed in other energy-intensive industries such as aluminium, calcium carbide, coke, glass, paper making, and alcohol.[14]

5.3. Buildings, transport and public awareness

Buildings are another priority target for government policies on account of the large amount of energy wasted in heating or cooling them once they are occupied. The key culprit is the construction industry itself. In addition to exhorting local governments to implement more effectively the existing building codes and to encourage the retrofitting of older buildings, a new state regulation has been issued banning the use of certain building materials, and also banning the import of energy-inefficient building materials and techniques.[15] During 2007 the central government took a number of steps to curb the ostentatious and wasteful construction practices of local governments. In April 2007 new approval procedures were issued for public buildings.[16] A Circular in November 2007 called for tighter control of new construction in order to constrain levels of investment.[17] To reinforce this constraint on speculative construction, another circular required property developers to pay the land use fee in one lump sum before construction starts, rather than in instalments as was allowed in the past.[18]

The government is also seeking to reduce the amount of energy expended in existing buildings for heating and cooling, especially in public and government buildings. The has established a nationwide system to monitor energy consumption such buildings[19] and city governments have raised the permitted levels of summer temperatures in public buildings and offices.[20]

As discussed above, great potential exists for future energy savings in the transport sector through further raising fuel efficiency standards in vehicles, replacing old vehicles, changing the structure of the road fleet, by encouraging the use of diesel and hybrid cars, and by investing in urban transport systems (He et al., 2005; Shen, 2006; Walsh, 2007). But there is little the government can do in the short-term. Indeed, efficiency of oil use is not yet as critical an issue as the efficiency of coal and electricity use, though it will become progressively more important as the use of oil in transport continues to grow (Shealy and Dorian, 2007; Rosen and Houser, 2007). As a gesture, the government ordered that government departments use vehicles with higher fuel efficiency standards and that departmental vehicles not be available for private use by employees.[21]

In addition to these measures directed at specific industries and institutions, the government is taking steps to raise the level of awareness of the energy challenges facing the country. The media have been encouraged to assist the government in monitoring energy use and saving, and in raising public awareness. Officials, even at the most senior level, give high profile speeches on the subject and television programmes urge citizens to find ways to save energy.[22] This message has been reinforced by turning off unnecessary street lighting in cities such as Beijing and Shanghai for short periods.[23]

5.4. Energy pricing

The pricing of energy is one area of policy which the government has chosen not to address in a robust manner. As international prices for coal and crude oil have risen, so have domestic prices for producers of coal and oil. The government has allowed coal prices to react to supply and demand, and so border prices for steam coal rose from about US$ 40 per tonne in 2004 to US$110 in July 2008 in line with international prices.[24] Inland, near the areas of production, coal prices are at lower levels but have also risen by a similar proportion. The government has sought to constrain the price of coal sold to power stations but

[10] 'China closes more small thermal power plants', Xinhua News Agency, Beijing, 15 August 2007.

[11] Interfax, China Energy Report Weekly, 'China cuts more than 8360 MW of small coal-fired capacity in H1', Vol. VII, Issue 27, 10–16th July 2008, p. 9.

[12] 'China Vice-Premier says outmoded iron, steel plants must be scrapped', Xinhua News Agency, Beijing, 28 April 2007.

[13] 'China reports drop in energy consumption, pollutant emissions in 2007', Xinhua News Agency, Beijing, 5 March 2008.

[14] 'Facts and figures: targets for scrapping out-dated production capacity for pollution control', Xinhua News Agency, Beijing, 3 June 2007.

[15] 'China's State Council solicits opinions on rules for energy saving buildings', Xinhua News Agency, Beijing, 3 July 2007.

[16] 'China calls a halt to luxury public buildings', Reuters, Beijing, 18 April 2007.

[17] 'Chinese cabinet calls for tighter supervision of new construction work', Xinhua News Agency, Beijing, 21 November 2007.

[18] 'Reining in real estate', China Daily Business Weekly 22–28 October 2007, p. 7.

[19] 'China to monitor government office buildings' energy conservation', Xinhua News Agency, Beijing, 27 October 2007.

[20] 'East China city says no air conditioning in offices under 33 degrees Celsius', Xinhua News Agency, Beijing, 24 June 2007.

[21] 'China orders curbs on government departments' car use', Xinhua News Agency, Beijing, 24 November 2007.

[22] 'China's Wu Bangguo urges media supervision on energy consumption', Xinhua News Agency, Beijing, 27 April 2007.

[23] 'Chinese cities promote 'energy saving' in blackouts', Xinhua News Agency, Beijing, 24 September 2007.

[24] Interfax, China Energy Report Weekly, 'Rise in coal prices continued at Qinghuangdao port last week', Vol. VII, Issue 27, 10–16th July 2008, pp. 30–31.

otherwise has not directly sought to cap coal prices. Likewise domestic crude oil prices continued to rise as the government allowed them to follow trends in the international markets.

In contrast, in its concern to protect private citizens and, to a lesser extent, industrial and commercial enterprises, the government has proven very reluctant to raise consumer prices for oil products, for electricity and for natural gas. Over the period 2005–2007, the government raised the factory gate and retail prices for oil products by 5–10% on a number of occasions, in the spring of 2005, in March 2006 and November 2007.[25] Together these represent an increase of about 30%, which compares with a doubling of product and crude oil prices on international markets. Though producer prices for electricity and natural gas were also raised by similar proportions, residential customers were protected from most of these increases. A reluctance to raise energy prices further was enhanced during 2007 by rising inflation.

By June 2008 China's government could no longer resist the pressure for further substantial tariff adjustments and it announced a round of price rises for energy products. Retail prices for diesel, gasoline and jet fuel were raised by 17–18% with immediate effect, taking gasoline to about 75 US cents per litre.[26] Freight rates on the railways rose by a similar proportion. At the same time the government put in place a range of measures to ensure that the poorer sections of society were not unduly affected. Subsidies to farmers, payable by unit area of land, would be raised, as would payments per person to poor families in both urban and rural areas. Passenger fares for rail, for urban and rural public transport and for taxis would be unchanged.

From 1st July 2008 wholesale electricity tariffs were allowed to rise by 5%. The burden of these tariff increases is likely to be borne mainly by the industrial and commercial sectors, as rural and urban households will be protected. Natural gas prices are also set to rise.

This manner of managing energy pricing has had two negative consequences. First, whilst coal mining companies and crude oil producers have been making large profits, those enterprises involved in the transformation of energy, power generators and oil refiners, have been sustaining substantial financial losses. The government has been granting partial compensation to the major oil refiners, Sinopec and PetroChina, but not to power generators. Second, the impact of rising energy prices on end–user behaviour has been dampened, especially for households and rural communities.

5.5. Targets for local governments

The aims, targets and measures outlined above, together with others not described here, collectively comprise the new energy conservation strategy. The logic of the planning process in China requires that any quantitative national target be allocated downwards to progressively lower levels of government. Thus each province, municipality and autonomous region has been allocated a target for the reduction of energy intensity by 2010. Little information appears to be publicly available on the exact level of individual targets and on how these targets have been set, though it is likely that they were reached through bargaining and negotiation, by reference to both the previous 20 years of energy performance in the respective province and by reference to the 2001–2020 energy plan.[27] Provincial governments were asked to provide detailed plans of how they intended to achieve their goals,[28] and they in turn established targets and objectives for industry and for lower levels of government.

At the end of 2006 Shandong Province established a quantitative assessment scheme to assess the performance of local governments which allocated a total of one hundred points to a number of different objectives. Of these one hundred points, sixty-five related to eight specific annual targets and objectives. These comprised quantitative measures of energy consumption, and also of water consumption. The remaining thirty-five points related to seven qualitative measures of efforts to enhance the management of energy conservation (Shandong Provincial Government, 2006b). The central government reinforced its support for this approach in November 2007 by issuing a revised scoring system for assessing local governments (State Council, 2007c).

Individual senior local government officials and the leaders of the major state-owned enterprises are also to be assessed on their performance, though no details are available on the systems of assessment.[29]

6. Performance and outlook

Since 2004 the government has become much more open with respect to the timely publication of detailed information relating to energy consumption. In 2006 total energy demand rose by 8%, down on the 10% rise seen in the previous year, and well down on the levels of 15% seen in 2003 and 2004 (BP, 2007).

The performance on energy intensity was not so impressive. Overall energy intensity rose by 0.8% in first half of 2006, but fell 1.23% for the whole year as the new policies started to be implemented.[30] As was to be expected there was a high degree of variability among provinces. The five most successful regions were Beijing, Tianjin, Shanghai, Jiangsu and Zhejiang, which are among the richer, more modernised, with a low level of heavy industry and thus they already have lower energy intensities. The worst performers included provinces which are either poor or heavily industrialised, or both, and have high energy intensities, such as Shanxi, Guizhou, Yunnan, Qinghai and Ningxia (State Bureau of Statistics, 2007a). However, it should be recalled that different provinces will have agreed to different targets and that these targets do not seem to have been published. Thus, it is not possible to evaluate how each province performed with respect to its own target.

Individual provinces have also published statistics for each of their selected enterprises in the top 1000-enterprises programme as well as for key cities. In Shandong Province, for example, the performance over the year 2006 of the key companies using the scoring systems ranged from 99% for the Jinan Steel Company to 70% for the Shandong Lunan Ferro-Alloy Company. Likewise, the scores for the cities varied from more than 90% in the case of Yantai and Qingdao to as low as 65% for Rizhao and Weifang (Shandong Provincial Government, 2007).

The first half of 2007 saw a continuing strong rise in energy demand, as much as 15% on an annualised basis in the case of electricity consumption. Indeed data released in November 2007 indicate only a slight decline in economic growth in the fourth quarter of 2007. The rate of growth of GDP in 2007 was be higher than in 2006, at 11.4% up from 11.1% in 2006. Fixed asset

[25] 'China raises gasoline prices 7 pc in response to high oil cost', South China Morning Post, 23 March, 2005; 'Oil prices raised, subsidies promised' China Daily, 27 March, 2006.

[26] 'China shocks with 18 pct fuel price rise', Reuters, Beijing, 20 June 2008.

[27] Discussion at seminar on 'Energy conservation in China–sectoral issues', organised by the Asia Centre–Centre etudes Asie, China Energy Programme, held in Beijing, 20 October 2007.

[28] 'Chinese government urges intensified efforts for energy saving, pollution reduction', Xinhua News Agency, Beijing, 3 June 2007

[29] 'China says energy efficiency key to performance of government, company leaders', Xinhua News Agency', Beijing, 3 June 2007.

[30] 'China's per unit GDP energy consumption down 1.23% in 2006', Xinhua News Agency, Beijing, 28 February 2007.

investment also rose, from 24.5% in 2006 to 25.5% in 2007.[31] The output of the energy-intensive industries continued growing as did the level of exports of steel and aluminium, despite tax measures to discourage such exports.[32]

In July 2007, the government reported that energy intensity had fallen by 2.78% over the first half of 2007. Energy consumption per unit of industrial growth fell by nearly 4% overall but was highly variable between industries. For the coal, steel, construction material and chemical industries the declines lay in the range 5–8%. The fall in the electrical power sector was only 2.5%, but oil, petrochemicals and non-ferrous metals saw a rise of more than 1% (State Bureau of Statistics, 2007b). Over the whole of 2007 the decline in energy intensity for the whole country was reported to be 3.27%.[33] Over the first half of 2008, the year-on-year decline was reported as being 2.88%.[34]

Whether or not the country does indeed achieve the target of a 20% reduction in energy intensity by 2010 is not critical. Rather, this target may be viewed as aspirational—a political tool to promote action.[35] It is clear that energy efficiency is now very high on the policy agenda of China's government, and the measures that it has taken show that a considerable amount of effort is being devoted to achieving these ambitious and praiseworthy goals. Over the period 2006–2010, it is indeed possible that the government will achieve its goal of reducing energy intensity by 20%.

The primary reason behind the potential success of the programme would be the government's decision to focus its efforts on those sectors which will yield the greatest short-term impact, such as heavy industry, and on applying those instruments which are likely to be most effective, in this case old fashioned command-and-control using targets and penalties. Despite its relative lack of authority at local level, the central government retains the capacity to implement short-term 'campaigns' with specific targets and timescales. At the same time, steps have been taken with respect to drafting regulations, setting technical standards, carrying out audits, establishing voluntary agreements, building government capacity and providing information and training; though much more remains to be done for these measures to be effective (Berrah et al., 2007; Wang et al., 2008).

Two other factors may lead to the achievement of the target for the year 2010. Firstly, a lack of trust in China's economic statistics persists, and data on economic growth and energy consumption could easily be massaged to produce the required energy intensity estimates. Secondly, the target for 2006–2010 requires an average annual rate of decline of energy intensity of about 4.5%. This is similar to that achieved in the 1980s and 1990s.

By directing its efforts at these types of administrative measures, China's government has indeed designed its strategies to suit the prevailing national political and economic conditions, a necessary requirement for a successful energy efficiency policy, as identified in Section 1 of this paper. But sustained progress on energy efficiency will require continuing efforts to implement these administrative measures as well as the deployment of a wider range of instruments, for example the greater use of economic and financial incentives, the integration of energy efficiency into other sector policies, and a greater efforts to encourage a change of behaviour and expectation amongst the citizens.

In China such initiatives will face at least four major constraints. Such constraints are commonly found in other countries and there are linkages between them (see Section 1 of this paper):

- an apparent unwillingness to use economic and financial incentives;
- an apparent unwillingness to integrate energy efficiency into other sector policies;
- the systems of political decision-making and public administration;
- a shortage of technical skills.

The first constraint is the apparent continued unwillingness on the part of the government to use economic and financial instruments to complement the preferred administrative approach (Berrah et al., 2007; Wang et al., 2008). Energy users see little economic incentive to save energy because energy prices have been tightly constrained. Those wishing to invest in new equipment or processes cannot easily gain access to finance, and tax incentives are inadequate. Though administrative instruments may be effective when applied to a relatively small number of target enterprises or institutions, the weakening of the central government's powers during the 1990s has rendered such instruments ineffective across the wider economy unless accompanied by suitable economic measures.

This unwillingness to raise energy prices, in part, relates to the second set of issues which are the economic and social policies which indirectly or directly affect energy consumption. In recent years China's economic and industrial policy has been devoted to promoting heavy industry, infrastructure and manufacturing. The construction boom, which has involved considerable waste, has been further encouraged by weak planning regulation, low interest rates, poor accountability of local governments and state enterprises, and straight-forward corruption. In the transport sector, the desire to promote the domestic automobile industry and car ownership seems to have prevented any possibility of integrating transport policy into the city planning process. Further, the government's insistence on keeping tight control on end-user energy prices derives from the desire to protect poor consumers as well as constraining inflation.

The third constraint relates to the systems of political decision-making and public administration in China. The formulation and implementation of effective policy relating to energy efficiency over a sustained period requires political commitment from the top leadership, pro-active participation from major actors at all levels of government and enterprise, and transparency and predictability in both the administrative and the economic policy instruments employed as well as in the legal system. Failures in the management of energy, natural resources and the environment in China can be attributed to a great extent to deficiencies in these respects (Ma and Ortolano, 2000; Andrews-Speed, 2004; Economy, 2004). Despite the steps taken by the government in the last few years to address these concerns, it is not evident that profound change has taken place.

The final constraint relates to an apparent shortage of skills relating to energy efficiency. Though hard data on this problem has not been available to the author, interviews in Beijing during the summer of 2008 revealed concerns relating to the shortage of skills within both local governments and industrial enterprises. Local governments appear to lack the knowledge and

[31] 'Chinese think tank forecasts 11.2% economic growth in fourth quarter', Xinhua News Agency, Beijing, 12 November 2007.

[32] 'Chinese cabinet tells local authorities to report energy saving plans', Xinhua News Agency, Beijing, 3 June 2007; 'Big rise in Chinese exports of steel and aluminium', Financial Times 24 August 2007, p. 7.

[33] 'China reports drop in energy consumption, pollutant emission in 2007', Xinhua News Agency, Beijing, 5 March 2008.

[34] Interfax, China Energy Report Weekly, 'China's energy intensity falls 2.88 pct year-on-year in H1', Vol. VII, Issue 31, 7–13th August 2008, p. 12.

[35] Discussion at seminar on 'Energy conservation in China–sectoral issues', organised by the Asia Centre–Centre etudes Asie, China Energy Programme, held in Beijing, 20 October 2007.

understanding of energy policy required in order to develop effective local strategies in order to achieve their energy efficiency targets. Likewise, many industrial enterprises appear to lack the technical management expertise required in order to adapt their practices and processes to enhance energy efficiency.

A final potential concern, which again appears not to have received much systematic research, is the degree of willingness amongst China's population to voluntarily adapt their behaviour to support government policy on energy efficiency.

7. Conclusions

Central to the outlook for China's energy sector are the government's strategy for energy conservation and energy efficiency, and the response of local governments, of enterprises and of the population. It is already evident that the government's current campaign is having some effect in the short-term, as inefficient plants are closed and new technologies introduced. The question is whether this trend of improvement can be sustained, or whether the country reverts to old practices and standards. Four variables are critical in this respect: the rate of economic growth, the structure of the economy, the energy efficiency of individual sectors of the economy and the behaviour of society at large. Substantial and sustained change in the patterns and quantities of energy use will require government policies to be successful in respect of each of these four variables. Success, in turn, may require changes in policy approach with respect to the structure of the national economy and to energy pricing, as well as changes in the systems of public administration.

In the meantime, past practice and recent evidence suggest that improvements in energy intensity will move in waves and that these waves of increasing efficiency will advance across the country in a number of ways: from sectors of the economy which are easily regulated to those which are less easily regulated; from regions with effective government to those with less effective government; from modernised areas which are de-industrialising to less advanced areas which are industrialising; and from wealthy and well educated populations which can appreciate the need for energy conservation and can afford the more expensive appliances, too poorer populations with less education.

The degree to which the government succeeds or fails in this policy initiative is of great significance to the rest of the world, for this will determine a number of behaviours and factors. These will include, for example, China's net import requirement for different forms of energy, the nature and scope of diplomatic measures taken by China's government to secure energy imports, the scale of pollution emitted from China through the use of energy, and, potentially, the economic and political stability of the country itself.

As a postscript to this paper, it should be observed that the economic stimulus package announced by China's government in November 2008 raises serious questions about its commitment to the energy efficiency policy. A slowdown in the economy would have allowed further measures to be taken to consolidate existing gains in energy efficiency. This new package is specifically designed to trigger a surge in spending on housing and infrastructure. At the time of the announcement it is not clear to what extent the government will be able to ensure that this spending does not result in a repeat of the increase in energy intensity seen 5 years ago.

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