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The Impact of Urban Development in China on Global Warming

JULIEN ALLAIRE

As a proportion of China's energy bill, the non-industrial sectors appear almost secondary, so great is the amount of industrial consumption. Energy consumed for transport, housing and services adds up to only half the energy required by Chinese industry. Yet, since the start of the reforms, total urban consumption has grown ever larger alongside the secondary or industrial sector. The structure of China's energy consumption has altered considerably during this period because of industrial changes and the rapid urbanisation of the country. Urban development has led to strong growth in energy consumption within these sectors.

During the Maoist period, urban development was limited. The regime fostered anti-urban sentiment and cities were designed for production. With the reforms, things changed. Surplus labour in the countryside migrated to the cities to work in the new areas of economic activity: in twenty-five years, the urban population tripled, exceeding the half billion mark by 2003. Over the period, there were marked changes in living conditions for urban households. Their purchasing power was reduced, apartments became more spacious and comfortable and the consumption of energy rose sharply.

Urban development can cause a city to emit more or less greenhouse gases according to the energy intensity of two specific consumption areas: thermal comfort and transport. The energy efficiency of these two urban systems, which represent a significant proportion of total energy consumption, is a key element in achieving the Sustainable City in China—as it is, moreover, in other countries where rapid urbanisation is in process. So the initial phase, the building of the city, is crucial. In effect, it fixes the city in a particular model of energy dependence.

Over twenty years, China has managed big reductions in the energy intensity of its industry. But how energy efficient is China's urbanisation? Are its housing conditions and transport energy efficient, or do they threaten adverse effects on the climate for decades to come?

In this article, we shall look first at the extent of urban development before going on to estimate the consumption of

fossil energy in building the cities. Then we shall examine the energy dependence that develops at the same time as the cities are erected, focusing on consumption related to housing conditions and transport.

Demographic explosion in the cities

The urbanisation of populations is statistically difficult to estimate, in China even more than elsewhere. The designation criteria for the urban population have been modified several times over since the start of the reforms, and one has to accept some margin of error. Here we take as our source the United Nations data, which have been adjusted to present-day criteria⁽¹⁾.

According to these statistics, the rate of urbanisation has officially increased from 17.9% in 1978 to 36% in 2000 and 40.5% in 2005. Thus, the urban population has tripled in twenty-five years, between 1978 and 2003, reaching a total of 520 million city dwellers. According to the UN, by 2030 the number will have risen to 870 million (see figure 1). So between 10 and 16 million newcomers are expected in the cities every year.

1. United Nations, *World Urbanization Prospects: The 2003 Revision*, New York, United Nations, <http://www.un.org/esa/population/publications/wup2003/WUP2003Report.pdf>, [site visited 4 February 2006].

Figure 1. Rural population and urban population from 1978 to 2003 (in thousands)

Source: United Nations (2004)

While these figures do allow us to estimate the urban demographic explosion, they do not give us a precise picture. There are elements within the urbanisation process that cannot be effectively estimated. First of all, there is the “floating population”, those people from the countryside who have arrived in the cities without residential permits: they are estimated at 20% of the urban population⁽²⁾. Then, one cannot ignore “latent urbanisation”, the industrialisation of rural counties in the east of the country that have not yet acquired the status of towns⁽³⁾.

Indeed, town status requires official approval. Towns, once designated as such, are entitled to financial grants from government, funding for investment, and for the improvement and maintenance of the infrastructure. The designation of new towns or the downgrading of old ones is thus a means whereby the state can accelerate or slow down urban development. In the mid 1980s, the central government relaxed its control over designating towns. Numerous rural counties or prefectures were then upgraded into towns⁽⁴⁾. These changes of administrative status were facilitated by the new development strategy favouring the cities (SEZs and open coastal cities) and industrialisation in rural areas⁽⁵⁾.

Faced with the rapidly increasing numbers of towns and cities, Beijing resumed control from 1997 onwards of the re-designation of rural counties. Central government reduced by more than 10% the number of cities with that status. In 2003, 660 cities were listed, two-thirds of them having populations of over 500,000 people. At that date, 174

cities were officially listed as having more than a million inhabitants, 33 of them having over two million (see figure 2). Between 1978 and 1998, 475 cities were created, whereas only 61 had been created during the thirty years of the Maoist period. Demographic growth within the cities and the increase in their number was reflected in an unprecedented surge of construction.

Rapid urban construction

This burst of city-building saw the creation of new cities and the rebuilding of those already existing. The construction of buildings and urban infrastructure expanded rapidly. Table 1 describes this development between 1990 and 2004. Within those fourteen years, built-up areas, road surfaces and sewage systems quadrupled. Over the same period, residential areas increased in extent five times over. Speaking generally, more than half China's buildings were built during the 1990s and that total was increased by half again at the start of the new century.

2. C. W. Pannell, “China's Continuing Urban Transition”, *Environment and Planning A*, vol. XXXIV, n° 9, 2002, pp. 1571-1589.
3. L. J. C. Ma, “Urban Transformation in China, 1949-2000: a Review and Research Agenda”, *Environment and Planning A*, vol. XXXIV, n° 9, 2002, pp. 1545-1569.
4. The procedure governing the change of status, from county to town, was validated in 1984, with the tacit acceptance at central government level of an amalgam of several enacted principles.
5. G. C. S. Lin, “The Growth and Structural Change of Chinese Cities: a Contextual and Geographic Analysis”, *Cities*, vol. XIX, n° 5, 2002, pp. 299-316.

Figure 2. Growth in the number of cities according to size

Source: China Statistical Yearbook

Since the start of the 1980s, growth in the national stock of accommodation has been faster than the growth in population. Living space per resident in urban areas has gone up from ten square metres in 1990 to almost 14 square metres from 2000 onwards. While the number of people per household is falling, living space is rising, though it is still far behind the average living space in developed countries, which is 35 square metres per person. So the outlook for the building sector remains good for decades to come.

Urban development is at the heart of China's economic growth, placed there by the transition from planned economy to market economy. Suppliers of raw materials have been under heavy pressure to respond to the growing demand for building materials.

Early on, the authorities sought to improve the energy efficiency of these very intensive industries, which were held back by archaic technology, inefficient production methods and ill-adapted industrial organisation. Thus, the Sixth Five-Year Plan (1981-1985) and the Seventh Five-Year Plan (1986-1990) had a significant impact on the energy efficiency of heavy industry. Over the period 1980 to 1990, it is estimated that 85% of the drop in the energy intensity of industry was due to falls in the intensity of production processes for chemicals, machinery, metals and building materials⁽⁶⁾. But as market pressures built up in these sectors, programmes for controlling energy became less effective. In the 1990s, the relative liberalisation of prices accentuated

this process still further. Yet, there is still a long way to go before reaching the levels of energy intensity in the developed countries.

In the industrial field, it is heavy industry that is responsible for nearly 80% of energy consumption. The highest consuming sectors are ferric metals and building materials, which accounted respectively for 30.7% and 21.4% of all industrial energy consumption in 2000. By itself, Chinese steel-making accounts for nearly 10% of the country's total consumption of energy. Industries supplying non-metallic materials, and most importantly the cement producers, also account for 10% of the country's total energy consumption. In energy terms, China's steel-making and cement-production are inefficient industries. Their production processes use about one-third more energy than those in developed countries.

The construction of buildings and infrastructure in urban areas are the main outlets for the national suppliers of raw materials. So Chinese cities have been built from materials with a carbon content one-third higher than in developed countries. What is more, the quality of these materials seems partly responsible for the buildings' low energy efficiency. After a twenty-year tendency for the energy intensity of the Chinese economy to fall, the increase over the early

6. J. E. Sinton and M. D. Levine, "Changing Energy Intensity in Chinese Industry: the Relative Importance of Structural Shift and Intensity Change", *Energy Policy*, vol. XXII, n° 3, 1994, pp. 239-255.

Table 1. Growth in city size and growth in urban infrastructures

	1990	1995	2000	2004
Ground-level area of buildings (millions of square metres)	3,980	5,730	7,660	14,910
Ground-level area of residential buildings (millions of m ²)	1,996	3,100	4,401	9,620
Length of roads (kms)	94,820	130,308	159,617	223,000
Surface area of paved roads (square kms)	892	1,358	1,904	3,530
Length of gas network (kms)	16,312	33,890	48,376	148,000
Area heated by central heating (millions of square metres)	213	646	1,108	2,160
Length of waste water network (kms)	57,787	110,293	141,758	219,000

Data: China Statistical Yearbook

2000s marks a worrying development. Energy consumption is increasing exponentially because of the pace of urban construction (the space occupied by buildings has doubled over five years). The high demand for raw materials is in large part responsible for this new tendency, taken together with the new urban demand. For the first time since 1980, the energy intensity of the Chinese economy is on the rise.

Alarming prospects for energy consumption in construction

Drawing up an urban balance-sheet for the consumption of energy and CO₂ emissions is not an exact science. On the one hand, the energy data is not helpful because the inventory of emissions is compiled at the national or provincial level. On the other, the geographic data depends on the definitions and limits accorded to the cities: sometimes these yield very contrasting results. Thus we shall attempt here to account for emissions for urban non-industrial purposes, based on national data ⁽⁷⁾.

The energy consumed in construction can be understood as being in addition to that consumed by the residential and service sectors. It represents a quarter of all the energy consumed in 2000 and is expected still to represent over one-third by 2020 ⁽⁸⁾. Figure 3 shows the total cumulative consumption by the residential and service sectors since 1990. We may observe a sizable drop in the consumption of coal

during the 1990s; a switching of energy sources during that same decade; and a return to coal in recent years.

Between 1990 and 2000, urban emissions of CO₂ from construction remained stable, but this development is associated with a combination of different dynamics observed since the start of the reforms. Firstly, the authorities invested heavily in energy efficiency programmes to reduce coal consumption. In addition, numerous technological and organisational improvements were adopted to solve various problems: the shortage of mining enterprises, mining accidents, atmospheric pollution in the cities, environmental damage in rural areas, overcrowding on the railways and wasting of resources.

Then, the more the Chinese economy was taken over by the market, the greater became the need for price reforms to control the consumption of energy. So from 1993 onwards, the authorities deregulated energy prices. Between 1993 and 1996, the price of coal tripled, the price of electricity went up by 3.5 times and oil prices rose by more than 4.8 times ⁽⁹⁾.

7. We offer these figures without including those for biomass, much used in rural areas. In terms of energy consumption, biomass would represent at least as much as the total for other residential and services consumption. We should remember that biomass is not counted in CO₂ emissions. It is considered as renewable energy so long as it is not consumed faster than biological renewal.
8. R. M. Yao, B. Z. Li, K. Steemers, "Energy Policy and Standard for Built Environments in China", *Renewable Energy*, vol. XXX, n° 13, 2005, pp. 1973-1988.
9. Oil prices went on rising after the 1990s because of the increase in world prices, whereas the price of electricity went up by very little between 1998 and 2003. By contrast, coal prices fell between 1998 and 2000.

Figure 3. Total cumulative consumption by residential and services sectors (1990-2005)

Data: Enerdata S.A.

In the second half of the 1990s, the fall in the pace of economic growth had a considerable impact on coke consumption. Experts are agreed that the officially declared growth rates were greatly overvalued. Indeed, the drop in the consumption of energy indicates a greater level of economic deflation over that period⁽¹⁰⁾. Lastly, the programming errors in the electronics sector in the early 1990s were reflected several years afterwards in an under-capacity of production, which also limited the demand for coal. In the end, we may observe a direct lessening in the demand for coal at the end of the decade. It enabled consumers to choose a better quality coal producing less cinder and having a higher calorific value. This phenomenon allowed the electronics sector to cut its coal consumption by thirty megatons and its end users to cut theirs, probably by the same amount⁽¹¹⁾.

The fall in the consumption of coal during the 1990s was reflected in the development of new energy sources. In 1980, in the residential sector, coal furnished 90% of the energy consumed. By 2000, it accounted for 36%. On the one hand, coal burning had become more efficient; on the other, new energy sources were developed. With the rebuilding of the cities, China's urban households used less and less coal for heating and cooking. Increasingly, they had access to electricity, to town gas, to natural gas and to district heating networks, as evidenced by the rate of growth of such networks (see table 1).

The pace at which consumers were turning to alternative fuels was remarkable. Consumption of gas, oil and electricity grew at an annual rate, for all three, of 30% over a period of fifteen years. Thus, consumption of electricity and oil grew six-fold between 1990 and 2005. Each of these fuels now provides a quarter of the total energy consumed in the residential construction and service sectors.

Two-thirds of the energy usage in construction goes into heating and air conditioning (see figure 4). Thermal comfort is therefore one of the key factors in the potential energy demand of developing countries. In China, district heating networks are considered three times less efficient than those in developed countries, climatic conditions being equal⁽¹²⁾. To achieve an improvement in the energy performance in this field, it seems necessary for heating sources and distribution networks to be upgraded. Above all, it is essential for buildings to be better insulated.

Ever since 1950, only the 15 provinces to the north of the Yangtse are entitled to central heating. To the south of the river, no heating system is deemed necessary. In the north,

10. T. G. Rawski, "What is Happening to China's GDP Statistics?", *China Economic Review*, Vol. XII, n° 4, 2001, pp. 347-354.

11. J. E. Sinton and D. G. Fridley, "What Goes Up: recent Trends in China's Energy Consumption", *Energy Policy*, vol. XXVIII, n° 10, 2000, pp. 671-687.

12. C. Barbier, "Secteur résidentiel dans les pays émergents et politique climatique internationale, *Idées pour le débat*", n° 5, Iddri, 2005, 34 pp.

city heating systems are based on archaic infrastructure designed by the local administrators. City districts were provided with little boilers, coal-burning and very inefficient. The old pipes were leaky and there was no provision for regulating or programming the supply of heat. So there was considerable wastage. For some years, the authorities have been attempting to renew the stock of boilers, so as to reduce coal consumption and improve the quality of the air in the winter. Most importantly, numerous combined heat and power plants were built helping to improve output of energy and to develop heating networks. The invoicing system has also been adapted to allow households to pay for their heating on an individual basis. Since 2003, bills are sent out to the end users and meters have to be installed in existing networks (which is already compulsory for new buildings).

To the south of the Yangtse, the concept of thermal comfort is relatively new, but it is of particular concern with the development of air conditioning. Electric ventilating fans are used, which provide warmth in winter as needed and coolness in summer. Since the end of the 1990s, this technology has been quickly developed. In 1995, there were about ten air conditioning units per 100 houses; within ten years there were over 70. A survey carried out in 1999 showed that 61% of apartments in Beijing had an air conditioner, 72% in Shanghai and 88% in Guangzhou⁽¹³⁾. The usage of these appliances depends on the local climate and on the cost of

electricity relative to household income. Generally speaking, in the big southern cities, air conditioning consumes more household electricity than anything else.

So air conditioning is a major factor in the growth of electricity consumption. For that reason, Shanghai's electricity usage for the summer is twice as great as for spring or autumn⁽¹⁴⁾. Thus, energy demand arising from air conditioning has a still more worrying impact on greenhouse gas emissions than that arising from heating: firstly, because the output from these appliances is very poor and their power requirement is very high; and, secondly, the leakages and recycling problems with these appliances can have a serious effect on the climate⁽¹⁵⁾. According to Long *et al.* (2005), the use of air conditioning in the richest provinces during 2005 caused emissions of 32 megatons of CO₂.

Apart from the energy efficiency of heating or air conditioning appliances, the thermal insulation of buildings is a crucial factor in controlling energy consumption due to heating and air conditioning, which in turn has an impact on the consumption of coal. Good insulation means lower energy demand for thermal comfort; so it plays a significant role in limiting China's emissions of CO₂.

From 1986 onwards, the state attempted to impose thermal standards on the design of residential buildings in the cold regions (the north, north-east and north-west). These standards were designed to reduce by 30% the consumption of energy for heating, as compared with non-insulated accommodation. Unfortunately, these guidelines were not compulsory and so were largely ignored. In 1995, the central authorities upped their demands, asking for a 50% reduction in energy consumption for heating in new buildings. For these standards to be applied they had to be endorsed by regulations issued by the provincial authorities. But these authorities do not always appreciate what is at stake. It is estimated that only 5.7% of buildings conform to the ruling because of poor communications across the country and the absence of any mechanism for validating the results⁽¹⁶⁾. In

Figure 4. Distribution of energy consumption in construction

Source: Yao *et al.* (2005)

13. D. Brockett, D. Fridley, J. M. Lin, J. Lin, "A Tale of Five Cities: The China Residential Energy Consumption Survey", ACEEE Summer Study on Building Energy Efficiency, 2002, www.china.lbl.gov/publications/crecs.pdf, [site visited 4 February 2006].

14. W. D. Long, T. Zhong, B. H. Zhang, "Le conditionnement d'air résidentiel en Chine", *Revue générale du froid*, Jan-Feb, 2005, pp. 25-28.

15. The refrigerating gases used in these appliances (Hydrofluorocarbons: HFCs) have an overall heating effect that is from 12 to 12,000 times higher than CO₂; they also contribute to the damage to the ozone layer. The Montreal Protocol relating to these substances allows China a period of grace during which it has no obligation to eliminate the release of these gases. China is merely offered incentives to switch to using elements less harmful to the ozone layer.

16. C. Barbier, *op. cit.*

absolute terms, out of the 5.5 billion square metres of buildings erected between 1986 and 2002, no more than 320 million square metres do conform to national guidelines⁽¹⁷⁾. That also corresponds to a reduction in emissions of 23 megatons of CO₂. Thus, out of the entire built-up area in all Chinese cities, only 2.1% conforms to national standards.

In 2001, the central authorities set new standards for the other Chinese regions, thus extending to the whole country the objective of halving energy consumption for thermal comfort. Air conditioning was particularly targeted because of its growing use in the southern provinces, but the application of these standards remains at the discretion of the local authorities, some of whom do not enforce the regulations.

A programme for co-operation (on the French side, the Agence de l'Environnement et de la Maîtrise de l'Energie, the Agence Française de Développement, and the Fonds Français pour l'Environnement Mondial; on the Chinese side, the Ministry of Construction), has afforded us data on energy efficiency in construction. The first phase of this programme focused on building apartment blocks on sites totalling about 789,000 square metres in the provinces of Heilongjiang, Liaoning and Beijing. By building these apartments in line with national standards, yearly emission reductions of 44,000 tons of CO₂ have been achieved. This saving of 50% of energy consumption compared with standard equivalent accommodation was achieved in these cold regions at an extra building cost of around 7%. Unfortunately, without the programme for co-operation, no incentive was in place that might justify this extra cost⁽¹⁸⁾.

Conforming to national standards of efficiency in construction is essential for Chinese cities to rid themselves of such excessive energy consumption on heating and air conditioning. By 2005, buildings covering more than fifteen billion square metres had already been erected in Chinese cities. The low energy efficiency of these buildings doubles the consumption of energy for heating or air conditioning in these fully equipped apartment blocks. So Chinese urban development appears to be very energy intensive for thermal comfort purposes.

Alongside this worrying conclusion however we can emphasise some very positive developments in the provision of domestic hot water. For this purpose, representing 15% of the energy consumed in construction, China is exceptional in having very quickly become the world's leading market for solar water heating. In 2004, 13 million square metres of solar panels for heating water were installed. 90% are installed in an urban environment, of which 30% is in big cities and 60% in suburbs and smaller towns⁽¹⁹⁾. This market

is experiencing rapid growth and the National Development and Reform Commission (NDRC) is calling for the installation of 150 million square metres of solar panels in 2010 and 300 million square metres in 2020.

Growing motorization and physical constraints

The consumption of energy on urban transport is not based on the use of coal but of oil, of which China has been a net importer since 1993. During the Maoist era, consumption of energy on urban transport was very low. At the end of the 1970s, there were practically no motor vehicles. Cities were organised as collections of relatively autonomous work units. In these very densely populated built-up areas, commuting distances were reduced to the minimum. Pedal cycles and walking were almost the only means of travel.

In the 1980s, the cities began to spread outwards. This phase of urban development was driven above all by the rapid development of the bicycle. During the 1990s urban transport began to be organised around buses, taxis and minibuses used by enterprises to provide shuttle services. Speaking generally, walking and cycling still accounted, during the 1990s, for nearly two-thirds of journeys (see figure 5). Private cars were still more or less unavailable to Chinese households, but company cars were increasingly to be seen in the big cities.

With the development of the land ownership market and the housing market during the 1990s, social and spatial relationships between employers and employees diminished. Families now found themselves able to choose where they lived: consequently, commuting distances greatly increased. Industries moved outward from city centres, pushed towards the suburbs by growing land prices or by political pressure to reduce city centre pollution. The enterprises yielded their space to service industries and to prestige housing. So as the cities develop they become much less heterogeneous. This spatial reorganisation of urban activity led to a general increase in the length of people's journeys, which in turn made it more and more necessary for people to use motorised forms of transport.

17. Xinhua News Agency, 23 February 2005.

18. G. Rieb, A. Bernard, M. Bernard-Herve, "La construction en Chine", in Jacquet et al., *Regards sur la Terre*, Les Presses de Sciences Po, 2007, pp. 93-97.

19. W. Wallace & Z. Y. Wang, "Solar Energy in China: Development Trends for Solar Water Heaters and Photovoltaics in the Urban Environment", *Bulletin of Science, Technology & Society*, Vol. XXVI, n° 2, 2006, pp. 135-140.

Figure 5. Means of transport in various Chinese cities during the 1990s

Sources: various.

The early 2000s saw a real take-off in private car-ownership. Ever since 1994, the Chinese state has pursued a pro-automobile industrial policy. The authorities sought to make this sector of industry a pillar for economic growth; they supported the development of car-manufacture right across China⁽²⁰⁾. The aim was that in a few decades the country would have exporting businesses; it would favour their development by profiting from the resources of the domestic market⁽²¹⁾.

In March 2002, in his report on government activities, the then Prime Minister, Zhu Rongji, outlined the aims on car ownership. He proposed to equip 20% of households with cars by the year 2020. Starting in 2002, car sales rocketed⁽²²⁾. The national stock of cars doubled in four years rising from 8.5 million vehicles in 2000 to 17.4 million by 2004. This stock is particularly concentrated in the eastern coastal cities and the provincial capitals. Nationally speaking, the rate of car ownership is less than fifteen cars per 1000 people; but in the big cities it is more than fifty cars per 1000 people. Beijing has the greatest concentration of cars in China. Of the total national stock of cars 10% is concentrated there: ownership per 1000 people has risen to more than 100.

This rapid growth in the national stock of cars is reflected, of course, by a big rise in consumption of fuel. The vehicles sold in China have far lower energy efficiency than do vehicles of similar weight and size in industrialised countries. In

the Tenth Five-Year Plan (2001-2005), the state did encourage the production, independently of foreign car makers, of an economic Chinese car with a 1.3 litre engine. In fact, it was difficult to realise this aim, because foreign car-makers were reluctant to pass on their technology to Chinese enterprises and because fuel quality was still very poor⁽²³⁾.

Even though the stock of cars is growing very rapidly and the low energy efficiency of engines accentuates the increase in energy consumption for urban travel, China's urban transport is not tending towards energy intensity in line with Western countries. Admittedly, the increase in household income does increasingly permit car ownership; but physical constraints in the cities still limit the interest in using cars. Everywhere, in the richest cities, road congestion has become chronic. The time taken for car journeys has become considerably longer and rush hour average speeds by

20. Lin Gan, "Globalization of the Automobile Industry in China: dynamics and Barriers in Greening of Road Transportation", *Energy Policy*, vol. XXXI, n° 6, 2003, pp. 537-551.

21. S Stares and Z Liu, "Motorization in Chinese Cities: Issues and Actions", in S. Stares and Z. Liu, *China's Urban Transport Development Strategy*, Washington DC, World Bank, 1995, pp. 43-104.

22. We should note that the big Chinese cities advanced directly to the automobile. They bypassed the motorcycle to avoid atmospheric and noise pollution in the city centres. Yet, motorcycles proliferated in small towns and in the countryside.

23. J. Allaire, "Le casse-tête de l'Etat chinois: encourager la consommation automobile en décourageant la consommation d'énergie" (The Chinese Headache: Encouraging Car Use while Discouraging Energy Consumption), *Revue de l'énergie*, vol. LVI, n° 563, 2005, pp. 29-35.

Beijing: heavy traffic during rush hour

car are sometimes lower than those by bicycle. In fact, car owners in China are competing for the available space. Cities in China lag behind those in developed countries in terms of road space (see table 2). This continuing problem

Table 2. Area occupied by roads in cities, as a percentage of total city area – early 1990s

Washington	45.0 %	<div></div>
London	35.0 %	<div></div>
Paris	25.9 %	<div></div>
Tokyo	23.0 %	<div></div>
Seoul	18.0 %	<div></div>
Beijing	11.0 %	<div></div>
Guangzhou	6.4 %	<div></div>
Shanghai	5.0 %	<div></div>
Average for Chinese Cities	11.0 %	<div></div>

Source: Stares & Liu (1995), 2003 average: Cherry C (2005)¹.

derives from the density of the population, which in turn affects energy consumption for transport.

The population density of Chinese cities is at present above 10,000, even 15,000, persons per square kilometre. The prospects for greater car use should therefore be compared above all with developed Asian cities of similar population density. Thus, in 1990, the great agglomeration of Tokyo and Yokohama, with a population density of 7,000 persons per square kilometre, has car ownership of around 225 cars per 1,000 inhabitants. By comparison, American and European cities with average population densities of 1,400 persons and 5,000 persons per square kilometre respectively, had car ownership of around 600 and 400 cars per 1,000 inhabitants. The inhabitants of Tokyo-Yokohama emit an average of 1.2 tons of CO₂ per head from transport. In European cities, emissions from transport are estimated at 1.8 tons of CO₂ per head, whereas in the United States they reached 4.21 tons per head⁽²⁴⁾.

24. J. Kenworthy, F. Laube, P. Barter, T. Raad, C. Poboorn, B. Guia, *An International Sourcebook of Automobile Dependence in Cities, 1960-1990*, Boulder, University Press of Colorado, 2000.

Beijing : bicycles and car advertisement

In dense urban areas, because of the concentration of individual movements, the development of the motor car quickly encounters the obstacle of congestion. Collective transport systems are by contrast very efficient; they make it possible for large numbers of people to move about within limited space. Moreover, travelling on foot or by bicycle becomes easier when distances are shorter⁽²⁵⁾. The Asian cities, because of their density, have stronger incentives than Western cities for developing alternatives for motor transport. Thus, long-term use of cars will depend on whether cities can quickly find room for them.

This observation has been confirmed in China with the recent growth in the stock of cars. In consequence, to prevent congestion in the big cities, the Chinese authorities have planned big increases in public transport infrastructure. Taking account of the backwardness of public transport, they have since the late 1990s supported plans for building rail

transport networks in the big cities. In 2000, only 165 kilometres of metro or tram lines were in use: by 2010, a further 800 kilometres will have been built.

The consumption of energy on transport during the coming decades will thus depend above all on investment choices: decisions will have to be taken between railed infrastructure and road infrastructure, as well as between collective and individual forms of transport. Street design is also critical if non-motorised forms of transport are to be encouraged. The bicycle, which is still widely used across China, is the most efficient form of transport in terms of energy consumption. Whereas some cities are tempted to ban bicycles, city authorities should keep enough cycle lanes on public roads for as many people to use them as possible. The decisions reached regarding mass transport or non-motorised travel will

25. P. Newman and J. Kenworthy, *Cities and Automobile Dependence. An International Sourcebook*, Brookfield, Gower Technicals, 1989.

dictate the shape of Chinese cities and will thus determine their dependence on oil.

Conclusion

Urban development bears heavy responsibility for energy consumption and consequently for CO₂ emissions. Two sectors are particularly significant: thermal comfort and transport. Firstly, the question of thermal comfort seems in China to be of serious concern. The system of national standards does not work as it should. Because of the rapid increase in the national stock of individual electric appliances, and bearing in mind the low energy efficiency in apartment blocks, Chinese cities are developing high energy dependence on heating and air conditioning. That is reflected in a significant demand for electricity and coal. To reduce the contribution of the construction sector to global warming, the national recommendations need to be applied: new buildings must be better insulated and existing buildings should be renovated. Secondly, the rapid development of motor travel leads to ever higher consumption of oil and is restricted by shortage

of space. However, the congestion of city centres also favours the development of alternative solutions to private car ownership. Chinese cities could thus limit the energy consumed in travel by providing viable collective transport systems and by designing streets for non-motorised transport. If the present policy for investing in collective transport is pursued and spreads to medium-sized towns, it can lessen dependence on oil and limit the dynamic towards reducing arable land.

However, some elements of the Chinese model for growth are likely to threaten these positive developments. The development of the cities is beginning to have a significant impact on people's demand for energy. Urban growth is encouraged by improving living conditions. The central authorities are increasingly losing control of the demand for energy. With the expectation of rapid economic growth over the years ahead, these uncontrolled elements could hamper the effectiveness of government strategy in the fight against global warming. •

• Translated by Philip Liddell