Energy Efficiency and Urban Development
(the building sector and the transport sector)

CCICED Policy Research Report 2009

CCICED 2009 Annual General Meeting

November 11-13, 2009

Task Force Members

Co-chairs:

Yi JIANG, Member of China Academy of Engineering, Director of Building Energy Research Center, Tsinghua University

Laurence TUBIANA, Member of CCICED, Directrice de l'IDDRI, France.

Wei ZHOU，Member of CCICED, Vice Chinese Co-Chair of TF, President of Research Institute of Highway，Ministry of Transport

Task Force Members:

Qizhi MAO, Vice Dean, School of Architecture, Tsinghua University

Qiang LI, Dean, School of Humanities, Tsinghua University

Ye QI, School of Public Policy and Management, Tsinghua University

Yulin JIANG, Deputy Chief Engineer, CATS

Kejun JIANG, Senior Research Fellow, Energy Research Institute

Bertrand CHATEAU, Directeur d'Enerdata, France.

Albert BRESSAND, Executive Director, Columbia University's Center for Energy, Marine Transportation and Public Policy (CEMTPP), US.

Shobhakar DHAKAL, Executive Director, Global Carbon Project, National Institute for Environmental Studies, Japan.

Nick Eyre, Jackson Senior Research Fellow, Oriel College Oxford, Environmental Change Institute, University of Oxford

Lucienne KROSSE: Technologies, Comfort, Energy and Health, TNO

Partha Mukhopadhyay, Director, Centre for Policy Research, India

Mark MAJOR, Policy Officer of Energy & Transport, EU Commission

Support Experts:

Borong LIN, Associate Professor, BERC, Tsinghua University

Carine BarbieR, Research Fellow, IDDRI, France.

Shomik Mehndiratta, Senior Transport Specialist, The World Bank

Jimin Zhao, Research Fellow, University of Oxford

Suoxiang Chen, Former DDG of Department of Technology and Education, Ministry of Transport

Xiu YANG, PhD candidate, Tsinghua University

Jiayan LIU, Post-doctor, School of Humanities, Tsinghua University

Shengyuan ZHANG, Master student, Tsinghua University

Hui ZHAO, Post-doctor, BERC, Tsinghua University

Zhe LI, Master student, Tsinghua University

Qingpeng WEI, Associate Professor, BERC, Tsinghua University

Hongyang WU, Assoc.Prof, CATS

Zhenyu LI, CATS

Jingwen WANG, Tsinghua University

Lijie FANG, Post-doctor, School of Humanities, Tsinghua University

Jun LI, IDDRI, France

Chengjun LU, Post-dortor, Tsinghua University

Xumei CHEN, CATS

Yang LIU School of Humanities, Tsinghua University

TABLE OF CONTENTS

Introduction

Controlling energy consumption related to the daily activities of people in cities, hereafter referred to as "urban-life energy" use, is integral to mitigating the threats posed by hydrocarbon scarcity and climate change to China's development in the coming decades. Speaking before the United Nations (UN) in New York in September 2009, President Hu stressed China's determination to comprehensively tackle the challenge of carbon dioxide (CO_2) emissions and, consequently, climate change. Controlling urban-life energy use, with its dual goal of achieving high quality of life in urban areas in ways that also minimise energy demand and carbon emissions, is fully consistent with China's commitment and has the potential to make a significant contribution. While improvements in the performance of technical systems and supply side management are necessary components of this urban-life energy use goal, they alone will not be enough. Demand side management will prove equally, if not even more, critical, most notably through:

- advocacy and adoption of energy and carbon efficient lifestyles;
- development of cities with an urban morphology that limit needs for mobility;
- discouraging energy intensive consumption patterns through appropriate energy pricing and taxation.

With this in mind, the mandate of the Task Force was to investigate issues and formulate policy recommendations related to the potential for energy efficiency associated with various aspects of urban planning. The primary mission of the Task Force was to explore energy consumption associated with daily life in urban areas, hereafter referred to as "urban-life energy consumption". This term embodies four essential components of energy use:

1) energy use in residential buildings, such as for lighting, cooking, hot water, heating, cooling, and domestic appliances,

2) energy use in office buildings and other non-residential and non-industrial buildings, such as energy use for lighting, heating, cooling, office work and auxiliary appliances;

3) energy use in buildings used for leisure and entertainment, such as theatres, shopping malls, gym centres; and

4) energy use for urban passenger transport, including both public transportation systems and private vehicles.

Since the whole urban system includes, but also extends beyond, the four urban-life energy use components listed above, a number of issues relating to data availability and quality surfaced as a result. Existing consumption data and statistics were predominantly sector-based, and did not include separate statistics on urban-life energy consumption. To solve this problem, two approaches were adopted:

- For international comparisons, we used a proxy for urban-life energy consumption: a country's total commercial energy consumption which is comprised of the residential, tertiary and road transport sectors, sourced from Enerdata's Globalstat database.[1]

- For detailed city analyses, we used data based on surveys carried out in China, as well as data from international city comparisons carried out by the Task Force during the project.[2]

This report presents an exploratory undertaking by the Task Force that investigates possibilities for controlling the evolution of total urban-life energy consumption and related greenhouse gas (GHG) emissions in China. Part 1 of this report discusses why controlling urban-life energy consumption should be a priority for policy makers. Part 2 considers the critical policy issues needing to be addressed in relation to the urban-life energy use objective. Part 3 provides an overview of policy recommendations based on primary findings of the report.

Controlling urban-life energy consumption: a priority

This report's focus on urban-life energy consumption does not negate the importance of industry and agriculture-related energy consumption. On the contrary; in China, these two sectors account for approximately 70% of conventional energy use. Urban-life energy use, which accounts for a much smaller proportion of conventional energy use in the country, is currently lower on the priority lists of policymakers. Rapid growth at 7.4% per year over the last decade, however, means that the urban-life energy use will be responsible for increasingly greater proportions of China's total conventional energy use over the next two decades.

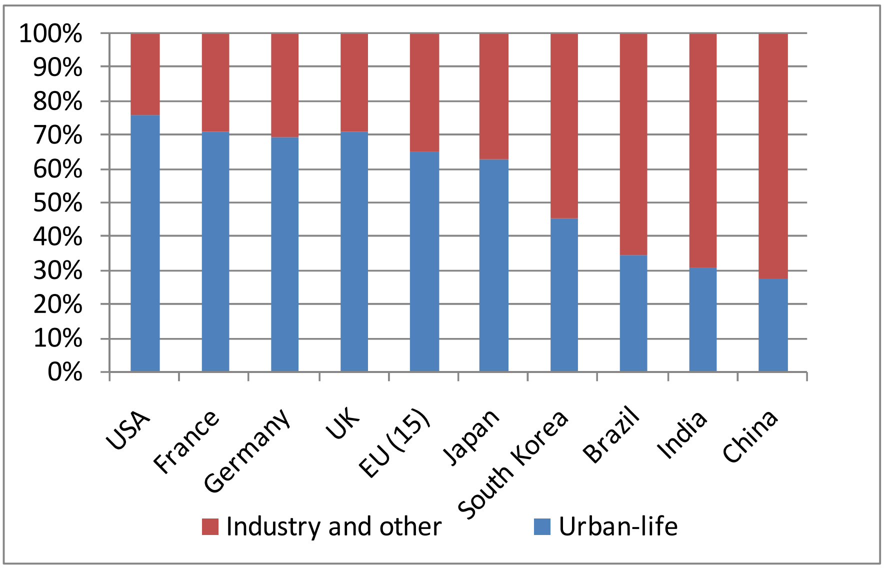
1.1 Why urban-life energy consumption is important

In 2008, energy use from building and road transportation sectors contributed only 27% to total commercial energy use in China. This figure is comparable to energy use in other emerging economies of the world, such as India and Brazil (Figure 1.1 overleaf). Yet the experiences of developed countries show that once industrialization is fairly advanced, the contribution to energy use from buildings and road transport tends to progressively increase alongside economic growth and changes to industrial structure fostered by such growth. For example, in OECD and EU member countries, energy use from buildings and road transportation accounted for 60% of total commercial energy use in 2008. In European countries where more detailed data are available (France, Germany, and the UK), actual energy consumption for urban passenger transport plus households and services accounted for more than half of total commercial energy consumption (Figure 1.1).

[1] Enerdata's GlobalStat database includes enhanced IEA statistics up to 2006, and data derived from various national, international and industry sources for 2007 and 2008 (www.enerdata.eu)

[2] Details on surveys and data sources for cities can be found in the main report

Figure 0-1 Share of urban-life energy consumption compared with total commercial energy consumption, by country (2008)



Source: Enerdata's GlobalStat database

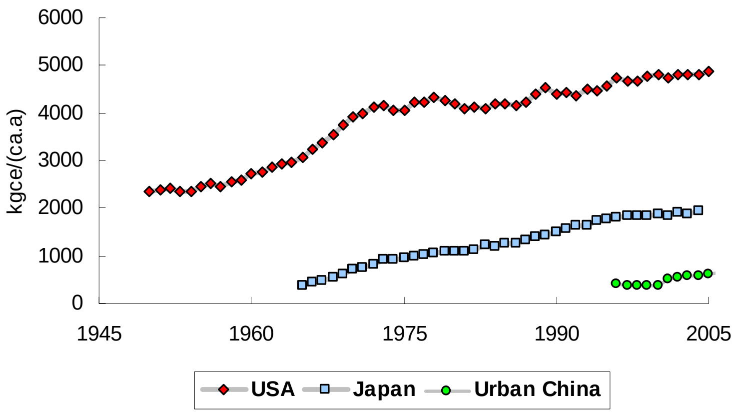
OECD countries are home to one sixth of the world's population, yet they are responsible for approximately half of total global conventional energy consumption, 58% of which is used for building and road transport. Furthermore, OECD countries account for 75% of global Gross Domestic Product (GDP). By contrast, the remaining half of global conventional energy consumption is accounted for by developing countries that are home to the remaining five sixths of the world population. Only 36% of this total conventional energy is ultimately consumed for use in buildings and road transport. In addition, developing countries account for only 25% of the world's GDP. The per capita energy consumption in buildings and road transport in OECD countries is therefore nine times higher than the average level in the rest of the world, and four times higher than the average level for urban populations in non-OECD countries.[3]

Per capita urban-life energy consumption for buildings and road transport in China is comparable to US levels in the mid 1950s, and Japanese levels in the late 1960s. Since then, urban-life energy consumption in the US has multiplied by a factor of three, and in Japan by a factor of two. If China follows urban consumption trends similar to those of OECD countries over the last century, dramatic increases in energy consumption can be predicted as the country develops through a rapidly emerging economy and enhancing living standards. Baseline scenarios for China run with the POLES model for the World Energy Council and the European Union indicate that urban-life final energy consumption has the capacity to increase by more than 300 Mtoe between 2008 and 2020, and by another 350 Mtoe between 2020 and 2030.[4]

[3] Statistics show that annual per capita urban-life energy consumption of Chinese urban citizens is about 0.54 toe, while the average level of American citizens is as high as 3.27 toe (Enerdata's GlobalStat, 2008).

[4] EU World Energy Technology Outlook 2050 (2006); WEC's "Deciding the Future : Energy Policy Scenarios to 2050" (2008)

Figure 0-2 Trends for building energy consumption per capita for some typical countries



Sources: US Census bureau, http://www.census.gov/popest/states/tables/NST-EST2008-01.xls; The Energy Data and Modeling Center. Handbook of Energy & Economic Statistics in Japan. Japan: The Energy Conservation Centre, 2008; Building energy research centre of Tsinghua University. 2009 annual report on China building energy efficiency. Beijing: China building industry press; 2009

If the per capita urban-life energy consumption levels of the four fast growing developing economies (Brazil, Russia, India and China, or BRIC nations) were to equal those of OECD 2008 levels, the world would need twice as much energy as it does today. Such a scenario implies an almost unimaginable strain on resources, taking into consideration presently available energy sources and environmental threshold capacities. The critical challenge, therefore, is to meet human development and welfare requirements while simultaneously keeping energy consumption and CO_2 emissions within sustainable limits. If this delicate balance is not maintained, ramifications on the world economy could be deep and long lasting, with drawbacks for all nations, including China and other fast growing developing economies.[5]

There is a marked difference between the goods production sector and other economic sectors (mostly building and transportation) on issues concerning energy conservation and efficiency. For urban-life energy use, which is strongly linked to the activities of daily life, energy conservation and efficiency solutions will not be entirely determined by technological breakthroughs. Better organization and management, energy prices, lifestyle choices and other non-technical factors all hold much greater potential for impacting energy demand and mitigating related GHG emissions, compared to similar efforts in the goods production sectors. In other words, whereas energy consumption and efficiency in the goods production sectors are highly constrained by the technical environment, for urban-life energy consumption, individual choices and decisions are key factors.

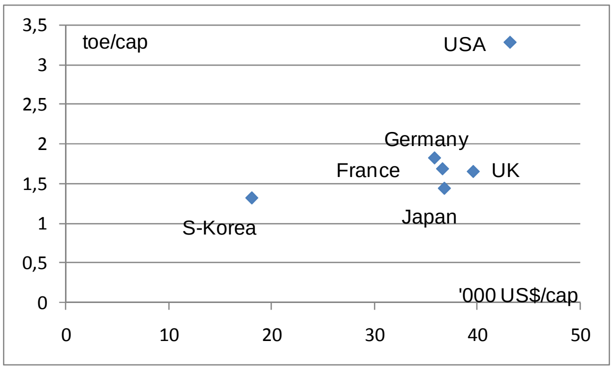
[5] The Stern Report evaluated the consequence of climate change on global and regional economies which appear to be far more important than the costs of mitigating CO_2 emissions (Stern Review on the Economics of Climate Change, 2006)

1.2 The critical issue: decoupling urban-life energy use from GDP

Unlike energy consumption in the goods production sectors, urban-life energy consumption is not directly driven by the production of goods, and therefore by the related generation of GDP. It is mostly driven by energy services provided to the people, which only partially contribute to the generation of GDP. When GDP rises, people accumulate more money, as more goods and services are made available to them, and as living standards increase. This is usually followed by increases in energy use, as demonstrated by the experiences of industrialized countries.

Although higher levels of per capita GDP are generally associated with higher levels of energy use, the correlation is not straightforward. Experiences from OECD countries at the individual country level have shown large differences among countries, not only with how urban-life energy consumption has been linked with GDP in the past, but in the present day as well. Figure 1.3 below shows that similar levels of GDP per capita can yield very different levels of per capita urban-life energy consumption.

Figure 0-3 Per capita urban-life energy consumption and GDP in industrialized countries



Differences in per capita consumption between the selected countries cannot be solely accounted for by climate, as shown by the comparison among European countries and between the USA, South Korea and Japan. The real reasons behind these differences have more to do with land use and urbanization patterns than with climate. To provide an example, let us consider the case of the US and Japan. They share similar levels of GDP per capita, but Japan's per capita urban-life energy consumption is considerably lower, at just under half that of the US level. This is to be expected: Japan has high population densities with people living in closer proximity to one another, whereas US populations tend to be geographically spread out with large distances between people and amenities. In addition, very low energy taxation in the US means that energy prices on the whole are much lower than those in Japan, with higher energy consumption in the US as a result.

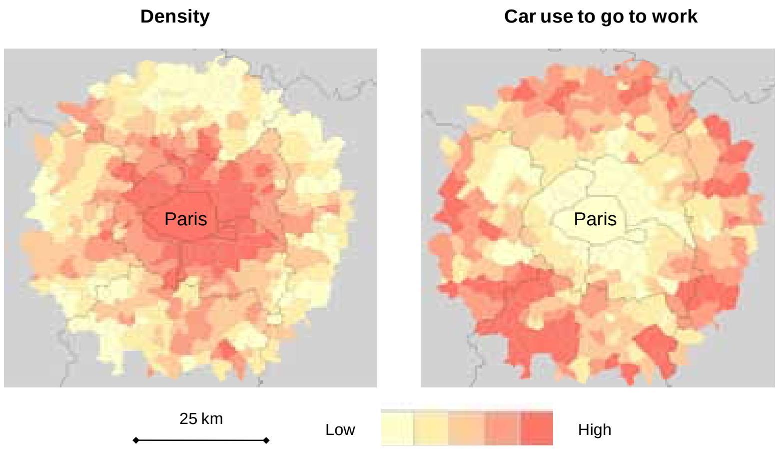
The case of the US suggests that the lower the energy prices and the more space available, the more extensive the urban sprawl, and the higher the per capita urban-life energy consumption, regardless of GDP per capita. Table 1.1 below compares road transportation patterns in the US and Japan. It shows that the per capita energy consumption for transport in the US is three times that of Japan, for a similar level of GDP per capita. Indeed, the US is a much larger country, requiring more intercity road transportation, but in both countries the vast majority of road travel is for urban and local distance purposes only.

Table 1.1: Road transportation and energy consumption in the US and Japan

	USA	*Japan*
GDP per capita	43.000 $	37.000 $
Average density	31 people / km^2	350 people / km^2
Number of cars per household	2,4 cars	1,2 car
Energy consumption of road transport per capita and year	1.820 koe	600 koe

Detailed comparisons between cities in Europe, Japan and the US were carried out by the Task Force to see if the above diagnosis could be strengthened, particularly with regards to the relationship between urban-life energy consumption and urbanization patterns.[6] The case of greater Paris highlights the issues. Figure 1.4 below compares the extent to which personal car use is determined by housing density, and examines associated energy consumption patterns as a consequence of daily activities.

Figure 0-4 Density, car use and daily energy consumption levels in greater Paris



Energy used in toe per year	*Paris (2.1 M inhab.)*	*1st suburb (3.2 M inhab.)*	*2nd suburb (4.1 M inhab.)*

Source: Task Force study on international cities comparison (see final report)

[6] The detailed results of this research are available in the final report

There are some well-known reasons as to why urbanization patterns play such a key role in the link between urban-life energy consumption and GDP:

- Daily travel distances to amenities and the work place are mostly determined by the size and layout of the city;
- Density of daily trips on main axial routes and the density of heat demand are mostly determined by a city's population, compactness and spatial layout;
- Building floor area is a driver of total building energy consumption. For example, over the last ten years China's per capita urban building floor area has doubled. As a result, building energy use has also doubled;
- Features such as building type, glazing, and natural ventilation are mostly determined by urban design and layout.

Another point that can be deduced from figure 1.3 (p.5) is that OECD countries may have similar GDP per capita with strong differences in urbanization patterns, which means that both features are not very strongly correlated. Conversely, the manner in which GDP is used depends upon the specific urbanization pattern of a municipality. The higher the per capita energy consumption, the higher the share of the income necessary to purchase energy and related equipment (a car for instance), and the lower the available income for purchasing more welfare oriented goods and services.[7] Hence, the claim that that more energy intensive urbanization leads to more welfare per unit of GDP does not always hold true; increasingly, research is showing the opposite.[8]

In summary, the collective experiences of OECD countries, in particular Japan and selected European countries, have demonstrated that urban-life energy use can be decoupled from GDP to a certain extent, with urbanization patterns and energy prices playing a much larger role. The Task Force believes that China may be able to go even further in decoupling its urban-life energy consumption from its GDP. First, it can benefit and learn from previous experiences of OECD countries. And secondly, with issues such as climate change and oil scarcity rising higher on the agenda, conditions will be more conducive to decoupling over the next two decades than in the 20th century.

1.3 Lifestyles: a key target for controlling urban-life energy consumption in China

At its core, urban-life energy consumption is strongly influenced by lifestyles and related consumption patterns. To further reduce urban-life energy in cities, greater emphasis will be placed on dominating social culture and values (for instance, one would feel, for those newly-built high-rise double skin commercial buildings, glorified due to their fashion, or humiliated due to their high energy cost and uncomfortable environment, etc.), individual choices and behaviours. Of course,

---

[7] JP Orfeuil's "Mobility, Poverty and Exclusion in France" (2003)

[8] On this question, see the recent report by the Stiglitz Commission to French President Sarkozy : "Report by the Commission on the Measurement of Economic Performance and Social Progress" (2009)

income levels matter, but they do not solely define consumption patterns: these are largely defined by the type of urban environment, amenities and physical organization of space in which people live, service price and availability, and the nature of value-driven criteria used for making personal decisions and choices.

The lifestyle policy challenge can be approached in terms of four 'pillars' that have the capacity to transform the Chinese urban landscape, as described below.

Pillar 1: Creating genuine Chinese patterns of urbanization

China is set to face a huge increase in the size of its urban population over the next 30 years, with 300 million new urban citizens being added during this time.[9] Despite presenting the country with enormous challenges, this situation could also create significant opportunities for policies aimed at controlling urban-life energy consumption. The challenge for policymakers is to accommodate this new urban population with much higher material expectations than populations in rural areas, without creating major drawbacks for the economy and the environment. Opportunities exist for designing genuine Chinese urbanization patterns in which the demand for energy services is maintained at lower levels (for example, through good accessibility with short distances), and good economic conditions allow the development of comprehensive energy efficient services (for example, public transport on dedicated lanes, efficient district heating etc.).

Pillar 2: Low energy intensity services that are available and appealing

Well-planned urbanization patterns are a pre-condition for decoupling urban-life energy consumption from GDP, but they are not enough. People can and will adopt low energy consumption patterns only if low energy intensity services for mobility and for heating and cooling and corresponding facilities are available and appealing. This is particularly important in supporting decoupling in the medium and long term. The majority of such services have to be planned in the early stages of urban settlements; service implementation costs rise with later stages of urban development.

Pillar 3: Selection of technical systems

Technical systems performance is determined truly very much by level of service provided, or demand of services in our urban-life. Most advanced energy carriers, designed for lifestyles of high energy consumption, are proved to be inefficient when operated in a saving mode of lifestyle. It indicates that innovations of technical devices and systems are necessary to fulfill requirements of sustainable green lifestyles, which uses less energy but with higher efficiency and helps maintain comfortable and healthy living of people. For instance, public transport systems cost much more energy than private vehicles, due to high no-load rate when there is strict time limitation of waiting for buses, but become appealing when prolonged waiting time is allowed to certain extent. The same thing occurs to centralized air-conditioning systems in buildings. They are proved to be efficient while there are

[9] Source: China Population and Family Planning Commission

needs of “full-time and all-space” cooling with requirements of constant temperature and humidity. However, housewives of those who prefer “part-time and part-space” cooling would choose split-type air-conditioners instead, since the electricity bill would be much less. Since there is no consistent set of technologies in China that could fully fulfill lifestyles of high energy consumption, significant chance emerges for China to develop suitable building and transport systems for green lifestyles.

Pillar 4: Promoting values which shape personal choices

To decoupling increase of urban-life energy use from GDP growth, corresponding social culture and values are needed, which impacts subtly people’s decisions to be healthy, nature-resource saving and environment-friendly ones. Admittedly, economic issues play significant role in decision making, yet proper pricing and taxing of energies could mitigate, to considerable extent, the impact of economic growth, while enhance considerations for other issues.

And it features significantly the fast developing cities that the culture, concept and values of citizens keep changing with expanding modernization and urbanizations in China. It is high time to cultivate new social and cultural values which are dominated by concepts of saving and the concrete base of green lifestyles. Then it becomes possible to achieve sustainable development with different urbanization modes from developed ones.

2. Decoupling urban-life energy use from income level increases in China

The drivers of urban-life energy consumption fall into one of two categories: 1) demand of energy services, and 2) energy efficiency of energy carriers. Controlling total urban-life energy consumption therefore requires control and appropriate reduction of the demand for services as well as the development of energy efficient technologies and systems to supply these services. Demand for services is mainly determined by urbanization patterns and related local lifestyles, cultural values and social organization, while the energy efficiency of energy carriers is more a function of available technologies. Both drivers will be further analyzed in the following subsections in relation to the urbanization process in China, along with a discussion of issues and challenges related to the decoupling of urban-life energy consumption from income level increases.

2.1 Growth trends of building floor space, urbanization and urban transport patterns

Thirty years have passed since the beginning of China’s economic reform. During this time, China's urbanization rate has been increasing at a much faster pace compared with historic urbanization rates of already industrialized countries (Table 2.1). The urbanization ratio for China was 17.9% in 1978, but reached 45.7% in 2008, with an annual increment of more than 0.9%. If the rate of urbanization increase remains stable, the urbanization level in China is expected to reach 47% in 2010, and 60% around 2030, the world average.

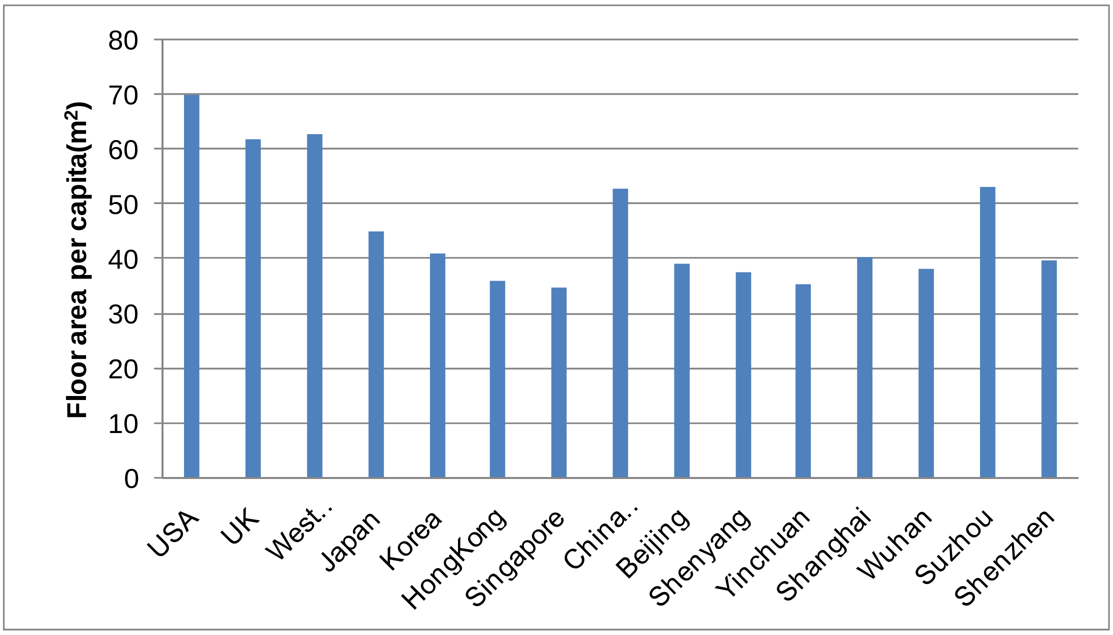
Table 2.1 When the urbanization ratio of some typical countries grows from 20% to 40%

Country	Britain	France	Germany	USA	Former U.S.S.R.	Japan	China
Year	1720-1840	1800-1900	1785-1865	1860-1900	1920-1950	1925-1955	1981-2003
Period	120 Years	100 Years	80 Years	40 Years	30 Years	30 Years	22 Years

Source: China's Urbanization Process and Space Expansion

In line with the fast pace of urbanization, per capita building area in China is increasing. Statistical data for China show that the current per capita urban floor area for residential and commercial buildings is nearly 30 m^2. This exceeds the corresponding index for Hong Kong, and brings the country closer to the average per capita urban floor area values of Japan and Singapore, currently about 36 m^2. In some instances, indices for certain Chinese provinces and cities exceed the average value of Japan and Singapore. Overall, however, China's per capita floor area is far lower than that of the US and Europe. Despite this, the last 15 years have seen a doubling of urban building floor area every 7 years, with more than 1 billion m^2 of buildings being constructed every year. If this trend continues, with 1 billion m^2 of buildings constructed each year, alongside urban population increases of 15 million a year, China's per capita urban floor area will reach 42 m^2 within 20 years, bringing it much closer to today's European levels. Total building energy consumption is almost certain to grow alongside increases in the building stock. If the urban building stock doubles, corresponding building energy consumption may undergo a twofold increase, potentially even higher. Surveys and analyses carried out by the Task Force indicate that, the peaking building stock is not in line with the real needs of increasing population. The driving forces hidden behind would only be clarified by further investigations and researches. If irrational motivations overwhelm other driving forces and yield up the building stock to an unnecessary and improper scale, a control mechanism for scales of urban construction and urban buildings may need to be established, to effectively restrain the unnecessary urban sprawling.

Figure 0.1 Per capita floor area comparisons between cities in China and selected countries of the world



Sources: IEA, AEI, Tonooka, Korean statistics, China Statistical yearbook

At the end of 2007, there are 655 cities in China, and their total built-up urban area was 35,470 square kilometers with 340 million residents, and the average population density is 10,294 per square kilometers; the actual building floor area in cities was 18.79 billion square meters, including 11.97 billion square meters of residential buildings. According to these data, the calculated per capita floor area of Chinese citizen, both residential and non-residential buildings included, reaches as high as 53 m^2/ca., exceeding levels of Japan, Hong Kong and Korea by far (Figure2.1). Yet it is notable that there are considerable numbers of buildings are serving immigrant workers in Chinese cities, so the real value would not be so much. However, it should be fully stressed.

Meanwhile, the proportion of so-called high-grade buildings, which are actually with high energy consumption, hikes in the newly-built buildings. Some high-grade residential buildings consumes more than twice of energy, in terms of unit area, as normal ones do, some glorifying office buildings more than quadruple. As is advertised, these buildings, truly, attained the developed level, but much more of energy use than of other bling-bling things in their posters. It seems in China that things are deviating from decoupling energy use from GDP growth by providing technical devices and systems suit for green lifestyles, but to, unwittingly, copying urbanizing routines of developed countries, and energy use.

The consequence has been a sharp rise in urban passenger transport volume and oil consumption. Since 1980, the year when urban residents' demands for transport started what has since been a continuous increase, passenger volume of urban public transport (including public buses, trams, and subways) has been growing steadily. In 2005, passenger volume reached 48.4 billions passengers-trips, which is 2.6 times greater than the level in 1980.

Generally, with the rapid development of urbanization and motorization, the basic problems of urban public transport in China have not fundamentally changed. There is still a conflict between road infrastructure development and efficient mobility services, and problems of traffic congestion in large cities have increased dramatically, resulting in shrinking quality and attractiveness of public transport. Though the modal share of public transport has risen from 10% to 35%, which is much higher than it ever was before, it is still lower in comparison to other cities of a similar nature in developed countries, where the average share of public transport is between 50% and 70%.

At the same time, physical space for non-motorized transport (NMT) modes has been dramatically compressed by the rapid development of cars. Overall, the share of public transport and NMT modes such as bicycles in Chinese cities has been gradually shrinking each year (Figure 2.2).

Figure 0.2 Modal Splits for Transport in Selected Cities, China

2.2 Following the OECD: Trends in China's Energy Consumption for Buildings and Transport

China's urban-life energy consumption constitutes a mere third of the country's final conventional energy use today, a figure similar to EU levels in the 1960s. However, over the last ten years, urban-life energy consumption has been increasing by 7.4% a year, in comparison to final energy consumption, which has been increasing at 5.9% annually.[10] In global comparisons, China, as the largest developing country in the world, is still experiencing a relatively low level of urbanization, and the per capita urban-life energy consumption for the country is not high.

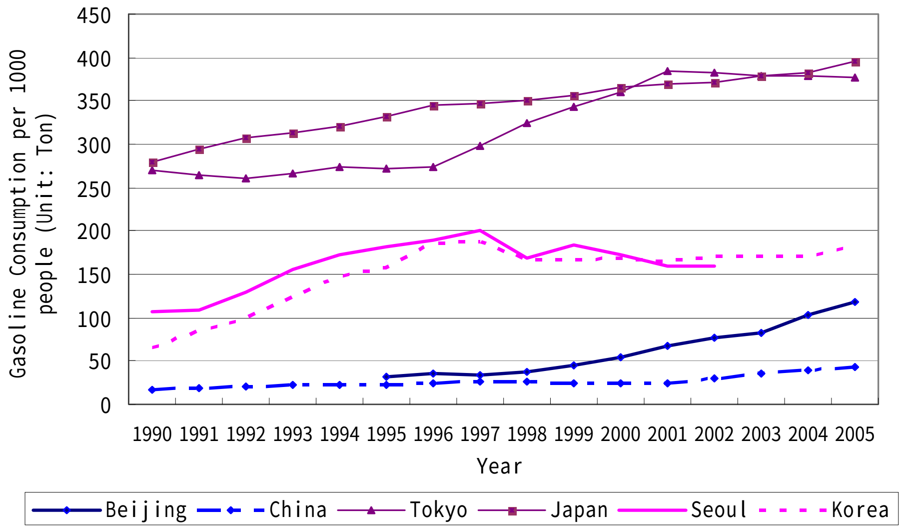
In 2008, China's total per capita commercial energy consumption levels for buildings were 10% of those in the US, and 17% of those in the EU and Japan.[11] For urban areas only, the per capita commercial energy consumption of buildings in China rose to 23% of levels in the US, and almost 40% of levels in Europe and Japan. For residential buildings, China's energy consumption levels per m^2 represented one third of consumption levels in the US and one half of those in Europe.[12] With a growing economy, improvements in living standards and under the influence of ideas of "a joint track with international standards" and "30 years of no backwardness", energy consumption levels for many high standard buildings in China have already reached industrialized country levels.

For the road transport sector, China's per capita fuel consumption has been increasing rapidly from 1990 to 2008, with an annual average increase of almost 9%. In absolute terms, however, China's per capita consumption is still minute compared to those of other industrialized nations. China's per capita road transport energy consumption is less than 15% of levels in Japan and Korea, 10% of those in the EU, and 4% of those in the US. However, narrowing the comparison down to urban populations only, the results for China become much more comparable to those for industrialized countries, with per capita consumption representing more than 30% of consumption levels in Korea and Japan, 25% of levels in Europe, but only 10% of levels in the US. Beijing, where the motor fuel consumption level is already three times higher than the national average, currently represents half the current average motor fuel consumption levels of Japan and Korea[13] (Figure 2.3).

---

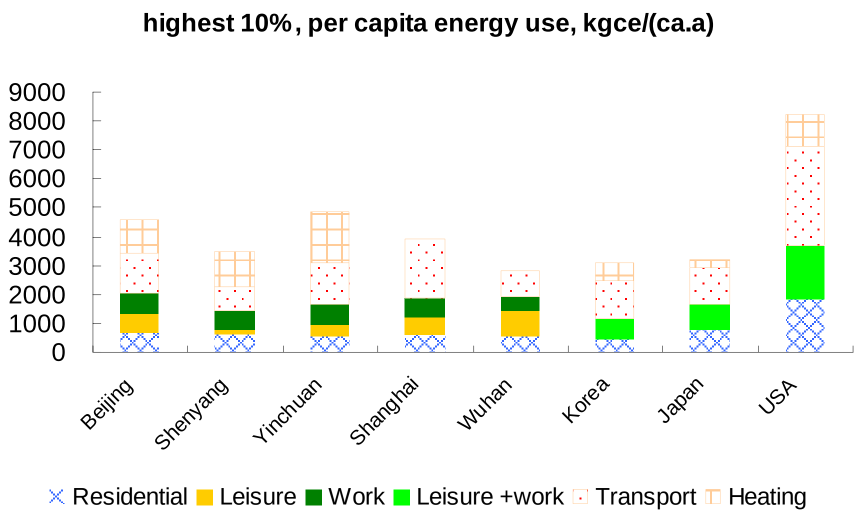
[10] Enerdata's GlobalStat database
[11] Enerdata's GlobalStat database
[12] Source : Building energy research centre of Tsinghua University. 2009 annual report on China building energy efficiency. Beijing: China building industry press; 2009
[13] Source: CATS.

Figure 0.3 Per capita gasoline consumption in China, Japan and South Korea



Surveys carried out by the Task Force showed that although the average per capita energy consumption value for Chinese citizens is still far from those of developed countries, the average per capita consumption level for the highest 10% of consumers in China is almost identical to the average for developed countries (Figure 2.4).

Figure 0.4 Urban-life energy consumption per capita in Chinese and foreign cities



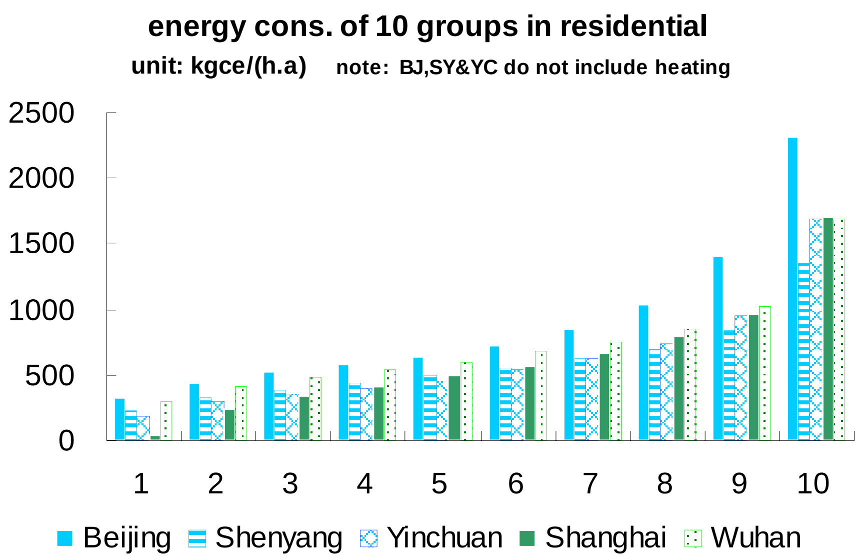
The findings from the review of current trends in energy consumption in buildings and road transport in China confirm initial concerns expressed at the beginning of this report. Should China continue down the same pathway of economic and urban progress that has characterized its development over the last few decades, it will come closer and closer to per capita urban-life energy consumption levels similar to those of developed countries today.

2.3 Discrepancies in per capita energy consumption among and within Chinese cities

A large-scale survey was carried out by the Task Force in six Chinese cities (Beijing, Suzhou, Shenyang, Yinchuan, Wuhan and Shanghai)[14] as well as several cities in selected developed countries. The aim of the survey was to compare and understand per capita energy use across different municipalities, both within and outside China, in a developing and developed country context.

Figure 2.5 below shows the distribution of the urban-life energy consumption (excluding space heating in Northern China cities) per household, according to consumption deciles (from the 10% households with the lowest consumption up to the 10% with the highest energy consumption), in five surveyed cities.

Figure 0.5: Distribution for urban-life energy consumption per household for survey cities (district heating energy not included for cities at northern China) [15]

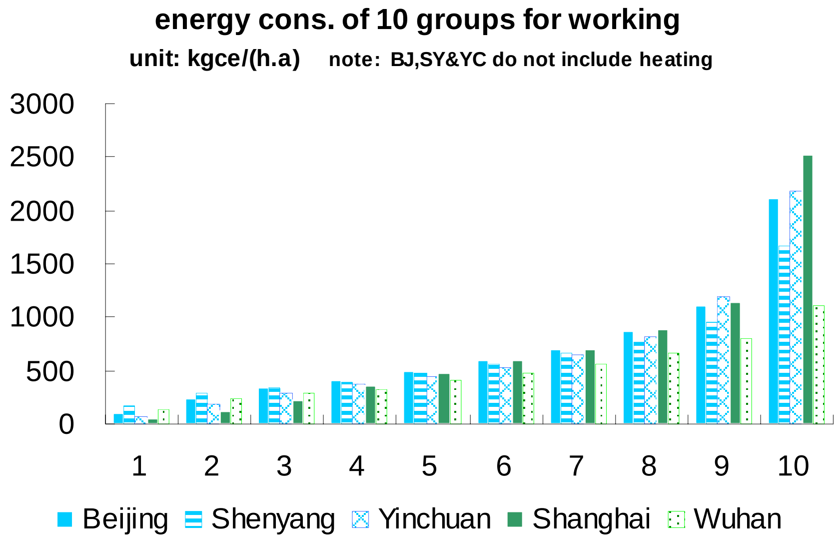


(a) Energy use in households

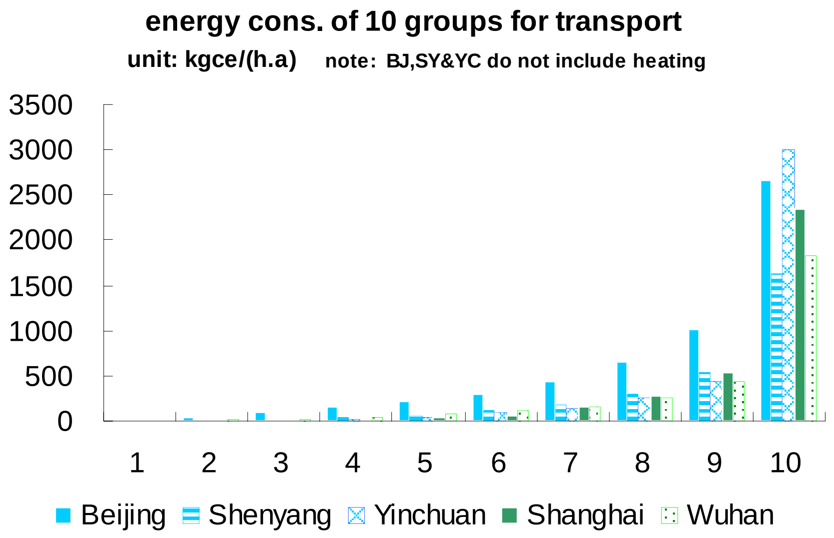
---

[14] For more details, please refer to the final report.

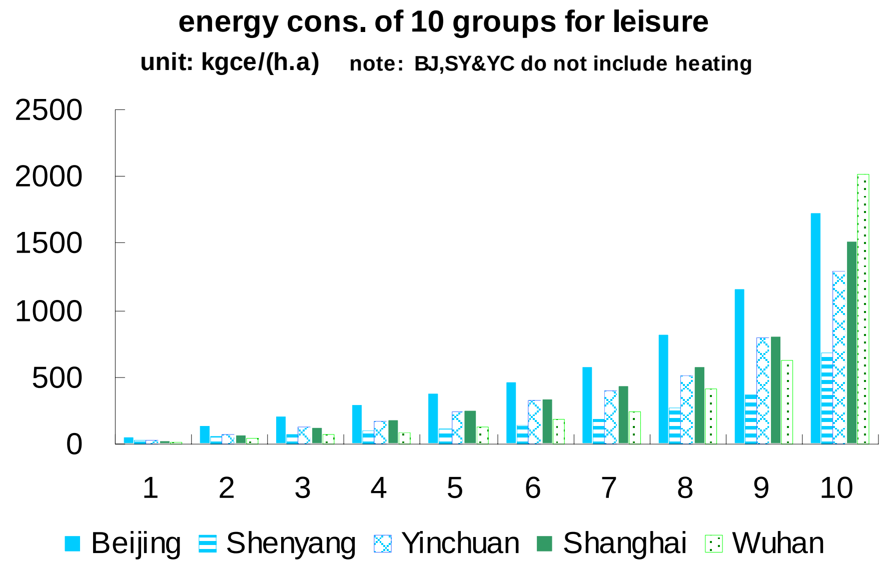
[15] Energy use for heating in Beijing, Shenyang and Yinchuan are not included in above results. The energy bill for district heating is charged according to served floor area, yet the heating fee of considerable number of residential buildings is paid by residents' employee. It is quite common in China that householders even do not know how much he has paid for heating. In general, district heating in China is kind of social welfare, which is not as in the market mechanism. As a result, the features of energy use of it are much different from others in consumption sector. So it accounts for the energy use in market separately, as (a) ~ (h) in Fig. 2.5, in convenience of analysis. In addition, the heating energy consumption is also illustrated in (i) of Fig. 2.5 to carry out parallel comparison with developed countries. Yet the data of developed countries are national average ones. For instance, the area that needs heating in winter in USA covers only 40%~50% of the total area of the country. While the domestic data are average ones within a city. As a result, the heating energy use of Beijing, Shenyang and Yinchuan are higher than that of developed countries.



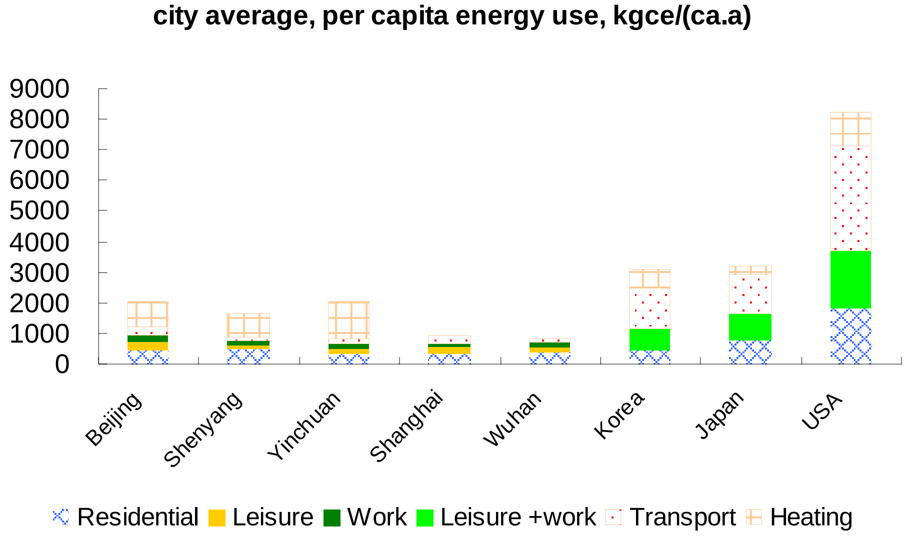
(b) energy uses for working



(c) energy use for transport



(d) energy use for leisure time



(e) average per capita energy use of each city

It is clearly that:

1. There are huge difference in energy uses in the consumption sector between the highest and the lowest groups. 20% people in the city from the highest consume same amount of energy as the 80% of the rest. However, no obvious correlations between energy use and income are observed (it will be discussed hereinafter).

2. Although the shapes of the distribution of energy use for different cities in China are very similar, the mean value for each city is quite different. It seems some correlation with the economic level of the city. And it could be further attributing to the cultural differences and corresponding habits of consuming and lifestyles, etc.

3. Although the average value for Chinese citizens is still far from the developed countries (5% to 20%), the average of the highest 10% is almost in the same level as the developed countries. This means it would not be very far future the Chinese energy use in consumption sector reach to the same level of developed countries if they follow the same trace of economic and urban development.

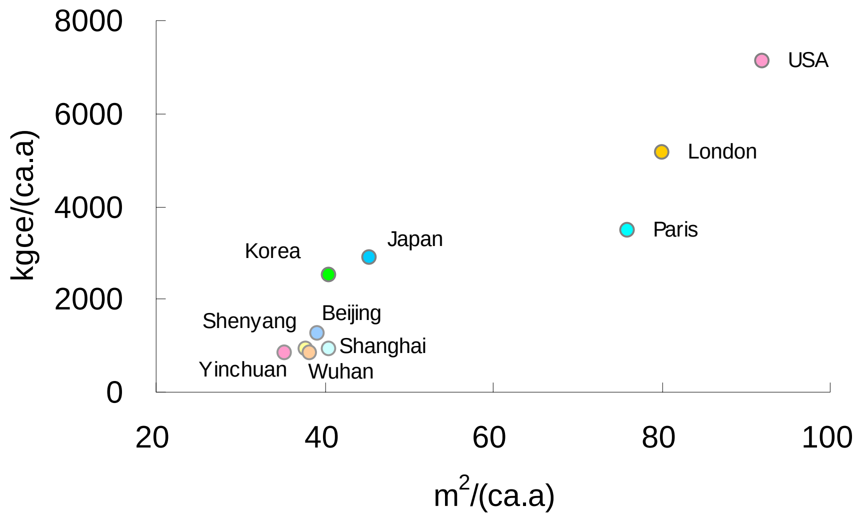
4. Distribution of heating energy consumption among different groups of people in Beijing, Shenyang and Yinchuan are quite even, which is quite different with other energy end-usages in consumption sector. It is observed that per capita energy use for heating in China is around developed level (see Appendix I), yet the energy use for other end-usages in consumption sector is much lower. The difference reflects well that the impacts of market and social welfare upon energy use in consumption sector are of great difference. This report will discuss possible policies to achieve energy conservation for heating through mechanism reform. So, the energy use discussed in following paragraphs does not include energy use for district heating system in northern China.

Following will be discussion on reasons for observed differences of each energy group.

Floor area per capita

Figure 2.6 below shows total building floor area in terms of m^2 per capita and per capita urban-life energy consumption for cities in China and abroad. The building floor area includes mostly residential and service buildings. One of reasons for the difference in energy use across the surveyed cities can be attributed to differences in the total building floor area. The greater the floor area, the greater the energy use.

Figure 0.6 Per capita urban-life energy use and floor area (residential and commercial)16



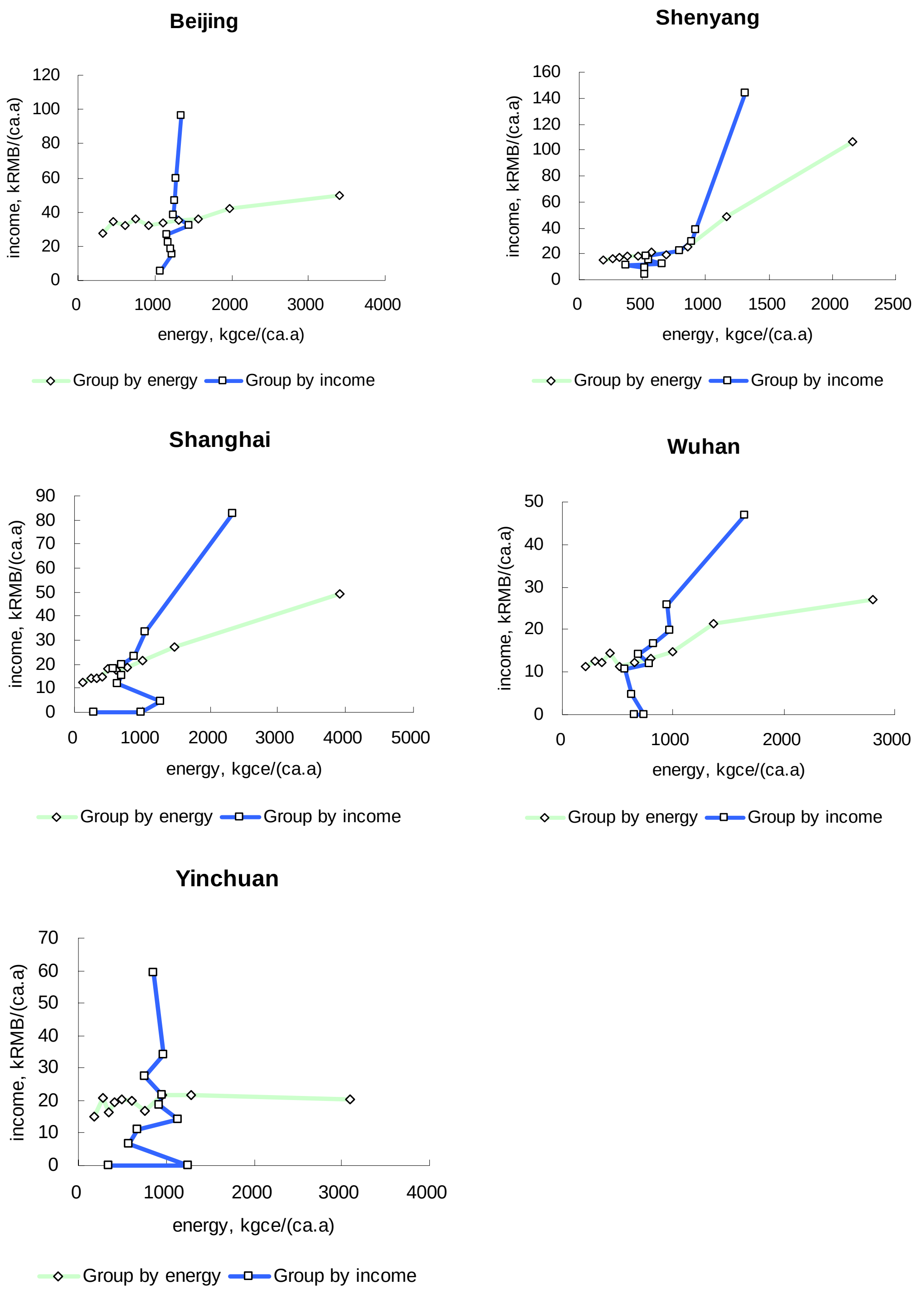
Income

Figure 2.7 below compares the distribution of the urban-life energy consumption per household according to two series of deciles: one based on energy consumption (green), the second based on income (blue). The purpose of this comparison is to show how far differences in consumption levels are explained by differences in income, and how far they are due to other factors, mostly related to lifestyles and consumption pattern. The bigger the angle between the blue and green lines is, the weaker the relationship between energy and income.

Figure 0-2: distribution of urban-life energy consumption levels in Chinese cities

Note: there are some groups whose incomes are 0 in the figures, due to they are supported by other members of their family. Since those supported do not have as much transport and work energy use as other members do, all members of a family are categorized into different groups according to individual income level.

[16] Data sources: Chinese cities - 2008 statistic year book for each city, along with investigations; Paris and London - see final report on international cities comparison; Korea - Korean Energy Economics Institute (2005), Energy Use Survey (2005); Seoul - Ministry of Commerce, Industry and Energy (2005); Japan - The Energy Data and Modelling Center, Handbook of Energy & Economic Statistics in Japan, The Energy Conservation Centre (2008); US - The United States Department of Energy (2008), Buildings Energy Data Book, US: D&R International, Ltd. (2008).



This figure clearly shows that the relationship between income levels and energy consumption levels is rather weak everywhere, and almost not significant in some cities (Beijing, Yinchuan). Although the Task Force did not have enough time to comprehensively investigate the differences among cities, helpful material to understand the reasons behind these differences has been provided by the survey and used by the Task Force. This is reviewed below.

Consumption patterns

Survey data for four of the six Chinese cities (Shanghai, Wuhan, Shenyang, and Yinchuan) were analysed by the Task Force sociologists at Tsinghua University in an attempt to further explore the underlying drivers of 1) observed differences in energy consumption per capita, and 2) personal attitudes towards ideal lifestyles. Four main drivers were explored: age, income, education and occupation. Detailed results and findings are featured in the in the final report; the main conclusions are as follows:

1. In each city, more than half of all respondents' attitudes to energy use in their daily lives were to maintain a certain degree of comfort while still attempting to save energy, with about 20-35% of respondents prepared to forego comfort in order to save more energy.

2. Respondents identified comfort and health as two of the most important characteristics of an ideal lifestyle. This has important implications for priority setting. Energy techniques need to be improved in order to meet people's demands for comfort which are as low in energy-intensity as possible. The relationship between health and behavior that promotes low energy consumption (for instance, cycling) should also be publicly promoted, in order to encourage healthy lifestyles and simultaneously discourage unnecessary energy use.

3. Of the four drivers (age, income, education, and occupation), age was the greatest determinant of attitudes towards energy use and lifestyles. It was observed that younger people tended to use more energy in order to maintain a more comfortable life, whereas older people tended to be thriftier with their energy use. In addition, the general focus towards personal healthiness was more prevalent in older people than in younger ones. Finally, younger people have more varied views on ideal life style than older people.

4. Explicit correlations between the other three drivers (income, education, and occupation) and respondents' attitudes were not identified in the analyses.

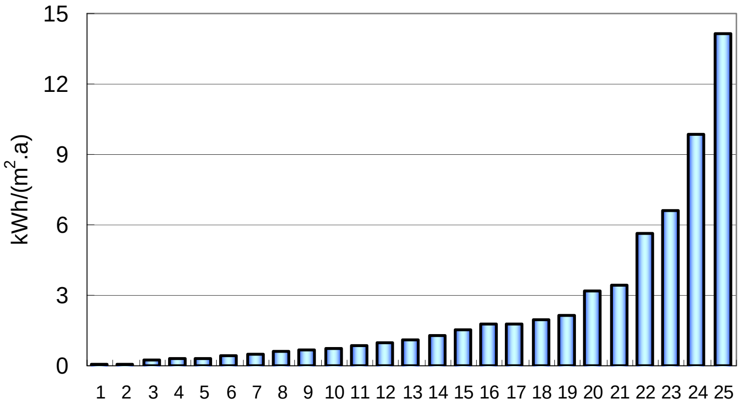
5. The answer to the question of why age influences attitudes towards ideal lifestyles and energy use lies in the rapid socioeconomic and cultural changes that have been transforming China over the last few decades. This has resulted a younger generation with greater and more complex lifestyle expectations, and has led to an abandonment of traditional customs emphasizing thrift and restraint.

6. Given that age was the greatest determinant of people's attitudes towards energy use and ideal lifestyles, China's future energy strategy should incorporate greater educational and awareness initiatives, as well as a reconsideration of the role of traditional cultural values in the context of energy use.

Another question needing to be answered for consumption patterns was "to what extent do social differences account for variations in energy consumption?" Figure 2.9 below shows electricity consumption of split air-conditioning units for 25 families in a residential building for employees of a design consultancy company. Every family unit was installed with two to four split air-conditioning units, and air conditioning electricity use per household was defined as the measured electricity consumption of each family unit divided by the building floor area of each unit. The primary reason for variations in energy consumption among different families is the air conditioning unit operation hours: the value ranged from 50 to 2000 hours per year. Some families use an approach to air conditioning of "part time and part space", while other families have adopted a continuous air conditioning approach, "full time and full space".

According to the survey, the operating hours, and consequently, the electricity consumption are not related to the income levels of each family, nor to the professions of the householders. The only correlation found was in the ages of each family. The data showed that the older the family the shorter the operation hours, and the younger the family the longer the operating hours. As mentioned previously, this is mainly a reflection of changing cultural and lifestyle norms.

Figure 0-3 Measured air-conditioning electricity consumption per household for certain residential buildings in Beijing

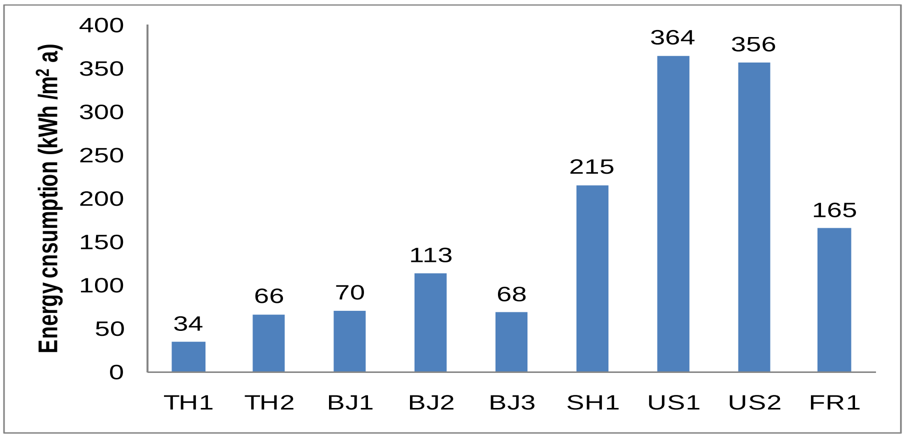


To provide a comparison with the previous example, a so-called "high energy performance" residential building in Beijing was installed with a high energy efficiency central air-conditioning system. The electricity consumption for the air conditioning system the same year that it was installed was 19.5 kWh/m^2. This is almost eight times higher than the average electricity consumption for the multifamily residential building in the previous example, running with split unit air conditioning systems. Although the "high energy performance" building did feature state-of-the-art technologies both in terms of building fabric and the air conditioning system, its overall electricity consumption was still considerably higher. This is attributed to the building's "full time and full space" approach, which contrasts with the multifamily residential building's general "part time and part space" approach.

Building working conditions

Details of energy consumption, including space heating, space cooling, electricity for chillers, pumps, fans, lighting and appliances, in surveyed office buildings in campus of Tsinghua University (TH), downtown Beijing(BJ), Shanghai(SH), Lyon(FR) and Philadelphia(US) are illustrated in Figure 2.10. It is very interesting that the overall energy consumption intensity per floor area varies from 34 to 330 kWh/m^2.a though the function and climate are similar.

Figure 0.4: Comparison for office building energy consumption in different countries



Note: TH represents campus buildings in Beijing, BJ represents a building in Beijing, SH in Shanghai, US in USA and FR in France.

One potential explanation is that the difference comes from the different service quality provided, consequently the working efficiency in those high service quality office buildings may be higher than the lower ones. However in-situ questionnaires showed that almost no complaints in the lowest energy office buildings such as TH1 and TH2, but a high frequency of complaints in the high energy intensity buildings. A question emerges from the survey as to why people need to pay huge energy bills to run the "high standard" buildings.

Urban trip distances and modal splits

Table 2.4 Travel distance and modal shares for various Chinese cities

City	Average travel distance（km)	Travel modal split (%)[17]	
		Public transport	NMT(cycling+Walking)
Yinchuan	8.4	20.7%	64.2%
Beijing	11.0	38.3%	27.7%
Shenyang	9.5	18.8%	68.1%
Suzhou	11.5	10.4%	44.4%
Wuhan	9.8	23.4%	61.0%

Table 2.4 shows the average daily travel distance and modal shares for five of the six Chinese cities surveyed (long distance travel for office and holiday trips are not included). Travel demand and share of public transport and NMT play a role in the

[17] Source: survey data from CATS.

determination of urban-life energy consumption (this is analyzed in details in the final report of the task force). Does longer per capita travel distance indicate a better life quality? Or is this a reflection of city size and urban lay-out? For any given travel distance, travel by car will be more costly than public transportation and than non-motorized transport. However, the greater the distance needing to be travelled, the more appealing the car is due to its advantage of speed, despite the downsides of cost and energy intensity. Rational use of private vehicles whilst creating an urban environment favourable to the development of public transport and NMT modes is a key component of urban energy saving.

The reasons behind these low levels of modal shares for public transport are investigated below:

- *Urban public transport legislation*

Currently, unified regulation making public transport a priority does not exist, for various reasons. The "Regulation for Urban Public Transport" is still in the consultation stages, which means that there is no strong legal framework for planning, constructing, operation and management of public transport developments. Therefore, requirements for land, funding, development rights and operational subsidies for urban public transport cannot be effectively implemented, construction is insufficient, and land for stations is not always available.

Urban public transport financing

Financing mechanisms need to be improved, as only limited subsidies are available from the central government. Management of public transport subsidies is carried out by local governments, which individually determine how subsidies are to be managed within the particular municipality. In the low public fares system, many public transport enterprises face operating difficulties. According to 2005 survey data, 80% of key public transport enterprises were running under deficit at the time, 12% were breaking even, and only 8% were receiving a surplus. In 2005, subsidies from local governments for 23 out of 36 cities amounted to 2160 million Yuan. A more recent survey in nine cities showed that public transport enterprises in eight of the cities were still running at a deficit. Furthermore, the survey showed that deficits can lead to instances of employee overtime (being employed for more than 10 hours per day) as well as generally low salaries for employees in public transport enterprises. This in turn threatens the solidarity of the employee team and the public transport enterprise operation as a whole.[18]

- *Allocation of urban space*

Weak coordination between urban planning, road construction and transport planning results in the shrinkage of public land specifically designated for non-motorized transport, and creates difficulties in the management of public transport, as emphasized above.

[18] For more detailed information, please refer to the full report

2.4 Findings of researches and surveys

Research findings have raised the following points:

1. Urban-life energy use is not determined by technological capacities alone; it is a reflection of societal lifestyles, cultural values, and associated habits. These qualities in turn are a function of the urban landscape, which plays an important role in determining demand for energy services. At the same time, total energy use is driven by total demand of services, with technology determining the energy use per unit of service demand.

2. Differences in per capita urban-life energy consumption may be related to differences in life quality levels. However, the relationship between energy consumption (which is related to the services used) and quality of life is far from linear. A small change in lifestyle may cause a huge increase in energy consumption, if it leads to a switch from a low energy intensity service to a high intensity one without significantly improving living conditions (switching from the metro to a car to go to work, for instance). In many cases, high demand of energy intensive services does not necessarily provide significantly better living conditions (such as those relating to health, working efficiency, and commuting time). Sometimes, the reverse may occur, with high demand for energy intensive services resulting in worse living conditions.[19]

3. Unlike the industry sector, where the predominant pathway towards reducing energy consumption is through increases in energy efficiency by way of technical improvements and innovations, reduction of urban-life energy consumption needs to focus on service demand control. Because the relationship between living conditions and demand for energy services is non-linear, controlling the increase and structure of demand for energy services may be the most effective measure. This is partly achievable through adequate urban planning.

4. Improving the quality of life for people should, of course, be the ultimate goal. The challenge therefore, is to encourage sustainable social models and structures which provide a quality of life that citizens like and make them happy, with the lowest levels of energy consumption possible. The current Western model cannot meet this goal sustainably. The Chinese government has expressed its willingness to “establish a society that could save resources and be harmonious with the environment”, which is in line with a new model of consumption. What is needed is the adoption of an inclusive, modern development model, which not only addresses the specific development concerns of China, but draws from development models from other emerging economies such as India, Brazil, Mexico and countries in Southeast Asia.

5. China’s low per capita energy consumption for buildings and road transportation can in large part be attributed to lifestyle differences, which can only partially be explained by differences in income. Therefore, the technologies needing to be

[19] Orfeuil (op cit) has shown that in greater Paris, people living far from the inner part of the city have no other choice other than very intensive use of cars, which is very costly, and in turn results in a relative poverty phenomenon.

implemented in Chinese buildings and transport systems, and the energy services required to control energy consumption should acknowledge such lifestyle differences rather than simply copying or imitating so-called energy efficient technologies from the West. The latter have been designed to accommodate for different lifestyle patterns which are inappropriate for China on a large scale. In addition, many energy services adopted from the West have resulted in increases, as opposed to decreases, in real energy consumption. In particular, support for the automobile industry as a pillar of economic growth has conflicted with the need to develop low energy consumption transport systems which minimize car use. Rebalancing support towards the development of "green" and innovative equipment and services, and improving the public transport industry may help China address this conflict.

6. Urban transport development provides vast opportunities for electric bicycle (e-bicycle) development. Public transport development in most Chinese cities is currently lagging, both in terms of incomplete infrastructure and poor quality of service. Statistics show that travel by public transport in cities with 500,000 residents represents approximately 10% of total travel, with only a few cities rising to 20%. In cities with less than 50,000 residents, public transport accounts for less than 5% of all travel.[20] This is not helped by the fact that the average speed of public transportation in China is only 10 km/h.[21] These percentage figures for Chinese cities are far lower than those for cities in Europe, Japan and South America. E-bicycle travel can save 50% of time used on public transportation, and 30% of time used by standard bicycle travel. Integration of e-bicycles in cities could simultaneously meet residents' demands for mobility in transport, and supplement the shortages in travel services arising from less advanced public transport systems. In 18 Chinese cities which permit the use of e-bicycles, e-bicycle travel generally surpasses that of all other forms of transport for a variety of travel purposes, such as to/from work and school, entertainment, family and friend visits, and suburb touring.

2.5 Controlling urban energy consumption in China: reformulating policy objectives

As is known, reduction of energy use for unit output of goods and materials plays the dominating role in achieving energy conservation in manufacturing and industry sectors. The more one reduced it, the more one would be efficient, even the total amount of energy use increases. It is reasonable since one would argue that more goods be produced. But for urban-life sector, the total amount of energy use is the ultimate goal. Services are goods and materials produced in urban-life sectors. If we merely focus on energy use of unit output, as is in industry sectors, total amount of provided services will inevitably hike in order to maintain a lower energy use of unit output. However, the ultimate outcome is that, on the contrary, the total amount of

[20] Ma Lin, Speech, Launch Meeting of the Transport Committee of China Urban Public Transport Association Application Forum (October 2006).

[21] Qiu Baoxing, Speech, National Conference of Prior Development of Urban Public Transport (December 2006)

energy use increases. As a result, considering present conditions in China, the ultimate goal for policies on energy use in urban-life sector could be: to further enhance quality of provided services in building and transport and standards of people's living, within current total amount of energy use, or even lower, and through technological breakthrough and innovations. Or policy objectives could hardly be achieved. The following section discusses a set of six mechanisms commonly employed, to varying degrees of success.

1) **Using percentage of reduction as a key target for energy efficiency**. It is widely used in current policies, in ways of, for instance, encouragingly, energy reduction of 50%, 65% and 70% in buildings, etc. These standards are evolutions of standards on heating in cold climate zone in northern China where there needs heating. Normally, if the U-value of envelopes reduces to 50% of current value, the heating demand would reduce accordingly to 50%, too. As a result, it is used as reference index to evaluate how energy efficient a building is. Yet in areas where the dominating energy demand are with cooling, appliances rather than heating, the energy use in buildings do not so much related with insulation, but much more with applied devices and systems, and demanded services of residents. If we simply look into insulation of envelopes in these areas, the course of energy conservation in China buildings sector would probably be misled. On the contrary, due to neglect of great impacts of lifestyles on energy use, buildings in name of 50% or 60% energy efficient but in real of more energy use than current level, would emerge.

2) **Using actual penetration rates of specific technologies to evaluate energy efficiency achievements.** For instance, insulations of external walls, low-radiant glasses and ventilating double skin façade, water or ground sourced heat pumps, etc. However due to climate, function and use of buildings (for instance, the interior heat sources, etc.), there are divergent requirements on buildings and systems, and further requires different technologies and devices for energy reduction. As a result, there is no such a technology that could meet requirement of energy reduction in buildings under all circumstances. On the contrary, blind use of some "energy efficient" technologies, without careful consideration of local requirement, would not only increase the investment, but also rise energy use in buildings. Blind use of technologies, in most cases, would force people to turn passively to a way of life with much higher energy demand, and consequently cause much more energy use in real conditions.

3) **Using percentages of renewable energy in the total energy demand of buildings or transport as key targets for commercial energy reduction**. This mechanism does not always successfully result in meaningful energy reduction and efficiency. Consider the following example: there are two similar buildings, Building A and Building B (with identical area coverage), but the energy consumption of Building A is 50% higher than that of Building B. Even if 20% of Building A's energy is supplied with renewable energy and 0% of Building B's energy is, the actual commercial energy consumption of Building A is still 20% higher than that of B. It is therefore misleading to label Building A as an "energy efficient building" merely because it employs renewable energy. In fact, when we mention energy efficient solutions, encourage of green lifestyles, or expanding use of renewable energies, etc., we are ultimately in the aim of reducing use of fossil fuels. So it should be prerequisite that the use of fossil fuels is less than normal ones when we are encouraging use of certain renewable technologies.

4) **Using energy efficiency standards as key indicators of energy savings**. Again, this may be insufficient if the policy objective is to control the total urban-life consumption level. For example, Mercedes- Benz car engines might be much more energy efficient than QQ cars (a low-cost Chinese brand of car), and therefore benefit from a much higher efficiency standard than the QQ. But if we consider actual energy consumption per km, QQ cars consume much less. Which car, then, should receive policy incentives in the form of subsidies? The same problem occurs when deciding on financial subsidies for public transport versus private cars, and technologies in buildings. Consider the following example. There is a residential estate in Beijing that uses radiant heating and an individual air conditioning system to maintain room temperature. In order for indoor temperature to be maintained at 24°C, $14W/m^2$ of radiant heating needs to be used, as well as $11W/m^2$ of the air conditioning system. The total actual energy consumption is higher than the reference value, which is 21 W/m^2 by local standards. However, building energy efficiency standards are evaluated under specific theoretical standard conditions: the working condition of applied radiant heating (24°C real) should be the standard condition, which is 18°C (then the theoretical energy consumption appears to be $10.5W/m^2$), and the energy use of air conditioning system is not taken into account because it is an added service. Evaluation of the energy consumption of this building in terms of efficiency standards yields a total value of only $10.5W/m^2$, which appears to be half of the reference value. But in reality, the building uses $25W/m^2$. Does it make sense to say that it is more energy efficient than the standard requirement? As can be seen, energy efficiency standards by themselves do not represent a credible mechanism for the controlling of urban-life energy consumption. Actual energy consumption should be the criterion of evaluation for energy efficiency.

5) Using vehicle flow as the main indicator of urban transport planning efficiency. To some extent, this may go against the objective and means of a policy aimed at controlling urban-life energy consumption. Indeed, what is really needed in urban transport planning is an improvement in the accessibility and travelling conditions for people. Up until now, the traditional urban traffic planning guiding ideology has been more aimed at to satisfying a car-oriented urban traffic system, which runs against the urban transportation energy and CO_2 emissions saving targets. In the practical process of planning and formulation, policymakers one-sidedly consider solving the problem of traffic congestion, which is thought to be the same as solving the problem of motor vehicle mobility. Therefore in urban planning, attention has been disproportionately biased towards car-oriented road construction. It is well known that the most energy efficient and environmentally friendly transport modes are first NMT modes and second, public transportation. However, the infrastructure required for successful implementation of NMT is being widely misappropriated, resulting in a worsening NMT environment. In fact, car-oriented urban traffic planning results in numerous restrictions on a whole range of activities, as well as accessibility, thereby seriously hindering the improvement of urban traffic operation efficiency and related energy efficiency.

6) **Using private car ownership levels as a key indicator for living standards.** This obviously challenges the objectives of a policy aimed at controlling urban-life energy consumption. As providers of mobility services, cars have a much higher energy intensity than other methods of transportation such as NMT and public transportation. The use of private car ownership as an indicator for living standards enhances the status symbol of the private vehicle, leading to sharp increases in private car fleets.

The idea that an individual car user should be completely accountable for his or her consumption of energy, use of road infrastructure, public space, and environment externalities, has yet to gain popular support. Neglecting the full social and environmental costs of private car ownership in turn reinforces car use and increases problems of urban congestion and environment pollution. Promotion of cars as status symbols results in decreasing recognition and acceptance of NMT and public transport as desirable providers of mobility services. Luxury, business and official cars are at the forefront of the status symbol phenomenon, and are increasingly becoming responsible for larger and larger shares of energy consumption and CO_2 emissions related to urban transport.

3. Policy Recommendations

Preamble

Energy demand of China in future is largely dependent on the goal of development and relevant policies. However, it is impossible for China to take the traditional routine of energy strategies, which is to first predict demands in markets, and then research the side of energy supply, and then balance between demand and supply. It is required to take fully into account the possible development of real economy and society, as well as the limitations of energies and resources, and optimize selection of strategic policies and tasks, to achieve a energy efficient society as a whole. Now the surplus production capacity due to over fast development is challenging China. It is urgent to take measures to restrain fast increase of energy use in building and transport sector. The answer for China would not be those for developed countries in the history, but be to achieve sustainable development with higher living standards and lower energy consumption and to construct energy efficient cities with Chinese characteristics.

Surveys, and notably the original surveys conducted in six Chinese cities for the preparation of this report, show the co-existence of multiple lifestyle and consumption models, with very different consequences regarding energy consumption levels. On one hand, one can still detect the strong influence of a "historic" model, rooted in Chinese cultural values and habits, that is associated with a fairly low level of per capita energy consumption; on the other side, one sees the rapid adoption of lifestyle and consumption models that are "imitative" of the OECD countries model and that lead to a high level of per capita energy consumption and greenhouse gas emissions. Undoubtedly, the rapid increase in household income in China is currently associated with the adoption of the "imitative" model by a part of the population. While currently this concerns only a limited part of the Chinese population the adoption of this imitative model is spreading rapidly in urban areas, in particular in the eastern provinces. This leads to growing social inequity as the majority of the population is faced with rapid deterioration in its environment and is not offered with models that it can afford to adopt to escape poverty. The spread of the "imitative" model would create very serious problems for the further development of China in the near future. The development of a harmonious society and the implementation of the policy directions set by President Hu in his September 2009 UN speech require that China limits the spread of this "imitative" model and develops a modern consumption model inspired from Chinese traditions. In addition to being sober in energy consumption and respectful of the environment, this model can make a powerful contribution to the achievement of a high quality of life by the majority of the Chinese population as China further urbanizes and develops.

Indeed, the original surveys conducted as part of this work programme have shown very clearly that, far from being synonymous with reduced social welfare, the lower energy use and carbon emissions associated with modern consumption models based on Chinese traditions can go together with high levels of satisfaction regarding the way people meet their building and transportation needs. This provides strong factual evidence that policies to “control urban-life energy” use can, simultaneously, promote patterns of urban-life energy consumption and related GHGs emissions that are sustainable and meet the needs and aspirations of the majority of the urban population. If accompanied with the right policies and the provision of appropriate services and infrastructure, lower energy use does not mean lower welfare and lower quality of life; on the contrary, it implies the opposite.

Currently, considerable amount of research institutes and individuals are focusing on energy, environment, economy and social development of China in 2020, 2030 and 2050. And many of them are taking GDP as decisive parameter to predict social and economic situations in future society, according to growth rate of current industries. Such forecasts and researches would definitely indicate very much energy demand in future and thus support to the export-oriented economy of China in future. However, considering the huge population of China, in order to maintain energy and resource-saving and environment-friendly economic and social development, it is needed, from now on, to carry out urban construction and guide economic development under instructions of energy efficient mode, which is scientifically developed under considerations of consumption demand, city organization and social modes in future, and could afford all people with life of good quality within limited energy and environment capacity and further achieve high civilization of Chinese nationality. The project has find some certain examples of low energy use and high satisfaction in building and transportation sectors. This issue can’t give the total path of the ideal city in the future. Further study on modes of resource-saving and environment-friendly urban society, is necessary and TF suggested CCICED to carry out a continued project at next stage.

The policy recommendations put forward hereafter address the pre-requisites and present the measures needed to implement such a policy to control urban-life energy consumption and related GHGs emissions. These recommendations stress the systemic character of this energy and carbon issue, and its strong relationship with lifestyles.

3.1 Set up a technical and economic framework for an urban-life energy use control strategy

Controlling energy consumption involves maintaining the path of energy consumption development on a pre-defined (low growth profile) trajectory, and controlling total consumption. For urban-life energy use, this applies to consumption at the individual city level. As pointed out earlier, statistics are not available which describe the complete characteristics of urban-life energy consumption, neither at the city level, nor the national level. Therefore, the development of such a statistical system is critical for the implementation and monitoring of an urban-life energy control strategy, and constitutes the first priority.

Attaining a desirable level of control over the total of urban-life energy consumption and of associated greenhouse gas emissions requires a set of mutually supportive, evidence-based policy measures. An evidence-based approach implies that policy measures be based on actual energy consumption of all types of building and transport activities, rather than on theoretical efficiency standards presently being measured in a fragmented, non-systemic manner. Similarly, policy achievements should be assessed on the basis of actual energy consumption data following policy implementation, and not on the theoretical efficiency gains claimed by equipment manufacturers or building constructors independent of actual usage figures. Adopting an evidence-based approach will enable the capture of the full effects of changes in lifestyles associated with the technical systems, as opposed to focusing on theoretical performances that ignore these effects. In this respect, financial subsidies that are based on theoretical efficiency standards rather than on actual energy consumption run the risk of being financially wasteful, as well as a source of energy waste and carbon emissions which could have been avoided. In parallel, pricing strategies need to significantly penalize consumers who consume more than a certain level, per m^2 or per person for example.

Proposals for action:

1. Set up a **national database** for urban-life energy consumption and GHG emissions covering urban transport and buildings at the city level. The purpose of the national database is to provide basic data for management, monitoring, evaluation and research purposes, as well as to inform scientific decisions and evaluations. Issues to consider include:

- the role of various institutions in data collection, at city and national levels;
- linkage with the national statistics system;
- format and functionalities of the database;
- content and capacity building;
- financial support.

2.Use actual consumption levels (at individual and city levels) to **design policy instruments** for controlling urban-life energy consumption. More specifically:

- set up actual consumption standards for buildings, as well as urban-life energy consumption objectives for individual cities, according to location;
- define the basis for standards and objectives, and elaborate the methodology for evaluating appropriate standards and objectives;
- Define push-pull policy instruments (subsidizing, pricing, etc.) based on standards and objectives.

3. Create a **National Institute for Monitoring and Evaluation** (M&E) to monitor urban-life energy consumption at the national and municipal level, and to evaluate performance against set objectives.

3.2 Promote healthy urbanization through urban scale, density and morphology

Urban planning rules and allocation of construction rights should be consistent with the goal of controlling the energy demand of urban systems. If urbanization maintains its present pace, and total building floor area in cities doubles by 2030, then total urban-life energy use is also projected to double, at least. The rate of urban construction needs to slow down to avoid over-supply. Urban development should insist on the principle of quality first, and a rational approach to total building area should be adopted in order to ensure that per capita urban-life building area (including residential and non-residential civic buildings) is smaller than those in Europe.

Some policies are already in place which addresses this question; however implementation is yet to come to fruition. The implementation of a property tax would play an important role in reducing oversized urban buildings. This would have additional municipal benefits, since local governments would not have to rely on selling land to ensure an annual stable fiscal income, and they could control more easily the speculative investment in house buying. Local fiscal income could then contribute directly to more sustainable development and improved housing situations of lower income groups in society.

Land use allocation is another critical issue for urban energy consumption. Urban morphology should be optimized in order to ensure shorter travel distances for residents. Public transportation networks need to form the backbone of infrastructure to serve future dense population distributions. A combination of mixed land use developments, services which are accessible and within walking distance (for example, shops, schools, health and fitness buildings, sports and entertainment centres, cultural centres, and green spaces) and high population density is required.

Proposals for action:

1. To accelerate the compilation and implementation process of the national urban system planning and land use planning, through the balance of national spatial planning to guide the scale, speed and rhythm of urbanization.

2. To combine the urban planning making and planning environment impact evaluation, to carry out a special research on urban transport demand and building energy demand, to reduce urban transportation and building's energy consumption. It includes: to guide urban development scale by phase, to optimize the urban structure and function layout, to search a compact development mode, as well as reasonable urban density and intensity, to enhance the mixed use of urban construction land, and to improve the urban comprehensive capacity.

3. Urban planning should insist the principle of quality first, and the total building area should be design rationally to make sure the urban-life building area per capita is not larger than 40 m2 (including the residential building and non-residential civic buildings), which should be smaller than that in Europe. In order to reach the goal, to control the yearly increased building floor area to about 700 million m2, which is far smaller than the present actual fact of 1.2 ~1.5 billion m^2.

4. Implementing Property Tax would be an effective measure to control the over-sized urban construction and contribute lots for energy saving in near future. If taking the major part of the property tax to local government for infrastructure construction and

solve housing problem of the lower class, the effect that the local government will not rely on the selling of the ground to ensure the stable fiscal income and control the demand of house buyers whose aim is investment and also the luxurious expense in some interpreters will be realized. The local fiscal income will be directly related with the municipal infrastructure construction, environment construction and the "livable cities", and thus improve the construction of the sustainable development, and also is the most effective way to restrain the overdevelopment of the construction of the cities.

3.3 Make mass transportation and Non-Motorized Transport (NMT) a national strategic priority

China is experiencing a declining trend in mass transportation and non-motorized transport, a trend which needs to be reversed quickly in order to facilitate low energy and low carbon urban development. In the context of urban transport, public transport and NMT are key mechanisms for energy savings in residents' daily lives. Public transport needs to be established as a priority by legislation, as does the establishment of a financing mechanism. Current management of public transport is not coordinated due to the lack of legislation. Stronger implementation of the National Development Strategy of Public Transport, therefore, is a top priority.

The attractiveness of public transport and NMT is determined by the speed, reliability, security and comfort these modes of transport can offer. Dedicated lanes for the exclusive use of public transport increase speed and reliability. Dedicated lanes for NMT ensure security and reliability. Allocating more public space for dedicated public transport and NMT lanes, and less space for personal cars, will drive up the quality of public transport and NMT services upwards and make the use of cars less attractive in mega cities. For new cities, and city extensions, this is a matter of securing space for public tranpsort and NMT in an integrated urban and transport planning context. For existing urban areas, it is a matter of space reallocation in existing streets and roads, which requires strong cooperation between transportation and public police authorities.

Public transport suffers from insufficient funding in many cities. Many public transport enterprises are currently running under deficit, and employee salary levels are below average. This results in decreasing service quality, which, in addition to congestion, increases people's reluctance to use public transport. Therefore, running alongside the priorities of appropriate public space allocation and the efficiency of public transport and NMT services, is the fundamental need for adequate funding for public transport and NMT services.

Building sustainable cities requires strong coordination between public authorities at the local, regional and national levels, and between different administrative departments within each level. Land use, construction, transport, energy and the environment are intricately related issues, with strong interactions needing to be addressed through integrated planning at both central and local levels. The integration of urban land use planning with urban transport planning needs to be strengthened through administrative reforms.

Proposals for action:

1. Set up a **special fund** for development of public transport, regulation of public fares, and a subsidies compensation mechanism at the central level, to be funded from private car use taxation (fuel tax, taxation of car purchase, possible congestion charges, etc.)

2. Formulate the 12th **5 Year National Plan** and a 3 Year National Action Plan for Urban Public Transport Priorities, along with annual action plans for public transport and NMT priorities in land use planning, construction investment, subsidies for public transport, road rights allocation, and policy support.

3. Launch the "**Legislation for Urban Public Transport**" as soon as possible, including the explicit requirement for establishment of an Integrated Urban Transport Authority (IUTA), at the level of each city to govern public transport networks, and plan and control operational services. Allow the local government to implement measures that discourage the use of personal cars and encourage the use of public transport and NMT.

4. Require urban master plans to guarantee the prioritization of public transport and non-motorized transport in the allocation of public space in new development zones and existing built areas (including parking places for cycles near bus stations, subway stations and other interchange transportation hubs and cycling lanes connected with public transport stations).

3.4 Deepen the reform of heat networks and systems in North China through institutional reform

It is widely recognized that large-scale district heating networks powered by high efficiency combined heat and power (CHP) plants present one of the best solutions for meeting the heating needs of urban buildings in northern China. CHP systems offer the potential for additional energy savings of 30% to 50%, compared to current energy consumption levels. However, despite the energy saving advantages offered by CHP, current trends indicate that district heating by CHP is being gradually replaced by heat pump and other individual heating systems. The reasons behind this are numerous:

1) no market mechanism exists in the district heating field;

2) district heating companies have to the responsibility of providing basic living conditions in order to maintain social stability; and

3) under the current system, district heating companies receive the majority of their income from initial installation fees, rather than from the operation of their services.

The ideal solution would be to measure and bill heat at the end-user level, and this is something which has been advocated for ten years now; however, it remains very difficult to implement. Therefore, we propose the implementation an alternative solution based on Nordic management modes for district heating.

Proposals for pilot action and experimentation:

1) Separate the management of the **primary network** from the existing district heating company, attaching it to the primary network of the company in charge of the CHP and peak shaving plants. Under this scenario, the district

heat company retains management of the secondary network and takes charge of end-use services. District heating companies pay for the amount of heat delivered from the primary network at heat exchange stations.

2) **Pricing**. Connection fees should be waived in order to incentivize district heating companies to provide good services that minimize heat consumption as opposed to merely expanding the number of connections.

3.5 Promote "green lifestyles" and encourage corresponding technologies

Lifestyles are a key target for strategies aimed at controlling urban-life energy consumption. This involves convincing citizens that “energy conservation starts with me” and creating a social atmosphere that collectively feels proud of energy saving, and ashamed of energy waste. It concerns itself with criteria that people use in their choices in everyday life - beyond the purely economic rationale.

The higher the energy prices, the more likely it is that these other criteria will influence decisions and choices of people towards lower energy use. Optimal energy pricing should therefore constitute an additional policy objective in the sense that taxation levels should fully reflect the negative externalities of energy use (CO_2 emissions, exposure to hydrocarbon scarcity) that the urban-life energy use strategy is attempting to reduce.

To an extent, people’s lifestyles can only become less energy intensive if the available technologies allow them. Therefore, technical systems which encourage highly consumptive energy behaviour should be progressively discouraged or limited through policy regulation.

Proposals for action:

1) Request educational NGOs to advise schools on **education materials**, such as applicable textbooks and relevant activities and competitions, at the primary, secondary and tertiary levels. Also, to relay the importance of energy saving in daily life and teach educational institutions how to cultivate energy saving habits in younger generations.

2) The various levels of Government should all **lead by example** and incorporate energy efficiency measures into government buildings and related transportation, which should be included as a significant indicator in government performance assessment. There should be public disclosure of energy use in large government buildings and fuel use of government cars.

3) Communicate a “green lifestyle” message through **mass media** such as logos at big events (for example, Olympics and Expo.) and on major landmarks. These should encourage energy saving or “green” lifestyles.

4) Central Government should establish **legislation** that identifies wasteful energy systems, as a function of location, which should be progressively prohibited or limited.

ACKNOWLEDGEMENT

The TF would express their best and sincere thanks to following people for their kind help and support, that are : Prof. Shen Guofang, Dr. Anthur Hanson, Mr. Guo Jing, Mr. Li Yonghong, Dr. Wang Xiaowen, Mr. Li Yong, Ms Zhang Ou.

Moreover, many thanks to domestic survey deparments, that are : statistical bureaus of Beijing, Shenyang, Suzhou, Yinchuan, Wuhan and Wenzhou, and Shanghai University.

Many people helped us to build the possibility for original survey, we'd like to thank them espeically. They are, Ms Chen Hong, the previous vice secretary-general of Shenyang municipal government, Ms Zhang Tailing (vice Chairman of Wuhan's S&T Association), Prof. Zhou Changchen from Wuhan University, Ms. Hu Yun, Dr. Chenhaibo and Dr. Zhouxiang.

Thanks to all who contribute lots for this report.

The report was provided by Task Force