WEC « Energy for Megacities » Study

Shanghai Municipality Case Study

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Summary

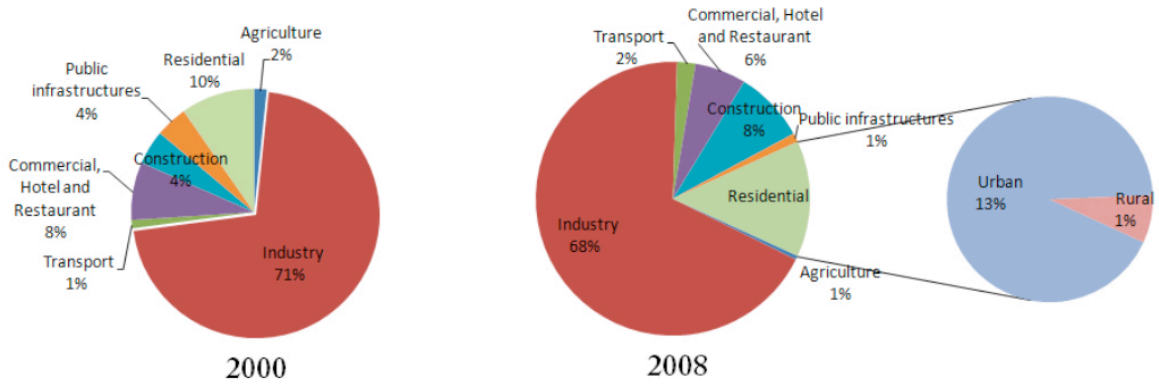
The city in a few numbers

- Population :	18,5 million people in 2009
- Density :	2600 hab/km^2 (up to 40 000 in the core of the city)
- Administrative Structure :	Shanghai Municipal Government (SHMG) has a government leader (Han Zheng) over government organs that are national subsidiaries at local level.
- Economy :	Shanghai accounts for 4,5% of national GDP ; 60% of overall workforce allocated to the tertiary sector
- Energy Poverty :	Shanghai residential energy consumption is growing quickly with the increase of Chinese living standards. Household electricity consumption was around 1618kWh/year/household in 2000 and raised to 2480 kWh/year/household in 2004

Energy consumption and GHG emissions

The energy supply mix of the city is also composed of coal, but in a much lower proportion than at the national level. Oil represents an important part of the mix, increasing over the years in order to equal the percentage of coal as supply primary energy. This is linked with Shanghai's rapid rise in vehicle ownership. Natural Gas contribution is minor but increasing, as well as the electricity coming from other sources, reflecting the increase of cleaner sources.

Figure 1. Evolution of Shanghai electricity consumption by sector



Source : China Energy Yearbook (2008)

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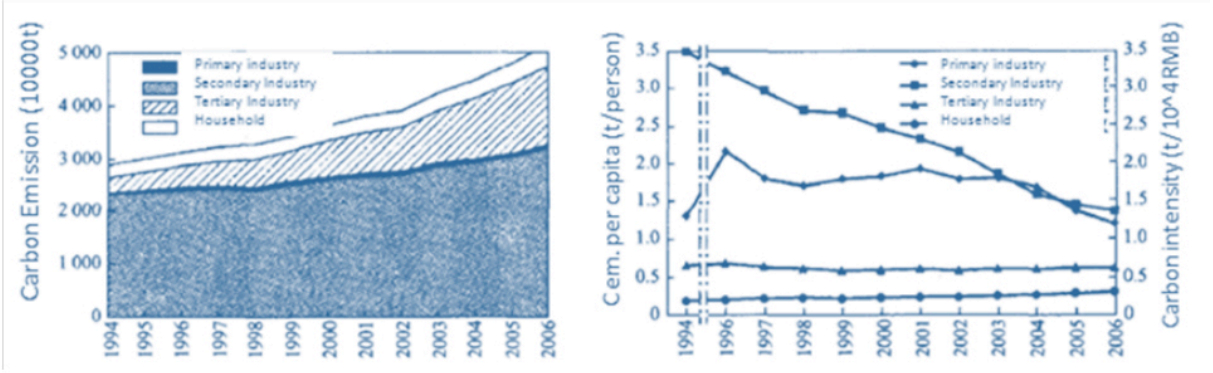
Being both a major industrial basin of China and the most developed city of the country -with capital city Beijing- with fairly higher living standards than the average, Shanghai presents much higher GHG emissions per capita than the rest of the country. It was 3 times higher in 2004 than the national value, and superior to most of European countries. But its GHG to GDP ratio is much better than the rest of the country, and has been constantly improving.

Figure 2. Carbon emissions and carbon intensity of different sectors in Shanghai



Source : Min & al (2009)

Plans and objectives

Shanghai strategies to reduce its energy challenges are divided in different categories :

- Develop renewable Energies
- Increase gas supply
- Improve energy efficiency, especially for industries, transports, constructions, new energies

Shanghai needs to reduce the proportion of coal in its energy structure as this primary energy source carbon emission factor is the highest. Even if the percentage of coal in the supply mix is decreasing, the number of tons increase quickly: from 26Mt in 1990, it has more than doubled in fifteen years to reach 58Mt. Therefore, control the coal growth is a challenge for the city, that can be reached thanks to improvement of the energy efficiency. Coal consumption mostly is an indirect reflexion of electricity use ; electricity mix hardly falls in the purview of Shanghai. As for industry, Shanghai wants to remain with an industrial base ; it is a political choice.

According to the 11th five-year national plan (2006-2010), the energy consumption per unit of GDP in Shanghai shall be reduced by 20% by 2010. Subsequently, Shanghai decomposed the indicator among the industries and departments in the Suggestion for Further Strengthening the Energy Conservation Work in Shanghai (2006). In addition, Shanghai issued Shanghai Eleventh Five-Year Plan for Energy Conservation, with amended parts similar to the national ones, and Implementation Plan for Energy Conservation and Emission Reduction in Shanghai (2007) to further determine the targets for its municipality.

New Regulations are effective from July 1, 2009, regarding rational utilization and energy conservation were ratified, for Energy Conservation in Industry, in Architecture, in Communications and Transportation, in Public Institutions and for Major Energy Users.

Main actions

On buildings

Shanghai Municipality committed in 2007 (in The Implementation Plan for Energy Conservation and Emission Reduction in Shanghai, 2007) to implement the standard that newly erected buildings shall follow a binding energy-saving 50 percent standard and would like to soon extend it to a 65 percent standard. Reaching the standard should be the precondition for getting a construction permit. With these measures, Shanghai expects to reach its building energy saving goal of 15 percent. Shanghai would also like to transform all public and government buildings into energy-saving buildings to give a good example to the construction industry. However, a study by the Chinese Ministry of Construction has shown that only 53 percent of the newly Chinese constructed buildings meet the set standards of energy efficiency. Although respecting energy-saving standards would only increase building costs by 5-10 percent, many real estate developers are unwilling to bear the costs, favoring short-term profits over long-term considerations.

On industries

The 2009 update of the Shanghai Energy Conservation push energy-conservation technology transformation in major energy-consuming industries such as electric power, iron and steel, petroleum processing, chemical engineering, building material and equipment manufacturing to raise the level of energy efficiency. It emphasizes on the efficiency of electric motors, blowers, boilers, furnaces, pumps and other equipment, and promote the adoption of technologies such as combined generation of heat and electricity (different to elimination of coal – see above), utilization of afterheat and residual pressure, optimization of energy systems as well as advanced detection and control of energy consumption. It also push the Shanghai power-grid enterprises to sign grid-joining agreements and electricity purchase agreements with renewable energy power enterprises and provide these enterprises with on-grid services such as switching-on, measurement and settlement. Finally Shanghai Municipal Government prohibits construction of coal- or oil-fired generator sets, or coalfired thermal power sets that fail to conform to the national standard.

On transportation

Under the guidance of the central government, urban public transport in China has demonstrated innovation leaded by regional and urban government. Unlike other public enterprise, the public transport has its own features, therefore can create special policies in different cities. The 3-year action plan on prior developing city public transportation from 2007 to 2009 targeted that public transport passenger volume will represent 65% of the whole vehicles, and 33% of all transport modes. Despite efforts already made in underground and surface public transports, in order to reach this goal, the construction of public transport infrastructure had to be speed up, the public transport management and service level strongly enhanced (strength the supervision of the public transport company) and supporting policy of public transport development were set up with long term mechanisms or purchase by the government.

On renewable energies

The Shanghai Green Electricity Scheme offers electricity consumers in Shanghai the opportunity to "green" their electricity consumption by buying some amount of green electricity for which a premium needs to be paid. To improve the energy efficiency in Shanghai, the Shanghai government not only adopted macro-control policies to address energy issues but also promote energy conservation idea from public awareness. The Shanghai experience shows that it is important to keep the local residence aware of the problem of energy conservation and environment pressures.

Shanghai Municipality would like to reach a wind power installed capacity of 200-300 MW in 2010. Space is limited in the Shanghai municipality and only allows three wind parks (Fengxian, Nanhui and

Chongming) to produce a total of 24.4 MW. Nevertheless, offshore wind farms bear a higher potential for Shanghai : 100 MW of offshore wind capacity are planned by 2009/2010 in Donghai. For solar energy, the target of Shanghai Municipality is to reach a production of 10 MW until 2010. Shanghai's power companies are also now financing nuclear power plant projects in nearby provinces. One illustration is the Qinshan nuclear power plant in Zhejiang province, which disposes of two 650 MW reactors and is planning two more 700 MW reactors.

Conclusions

At the national level it is increasingly sure that a carbon tax will see light in China during the 12th 5-Year Plan (2011-2015). However the details on what could be the measures for carbon cap-and-trade and/or tax in China are still debated. What seems clear is that a large set of measures will likely be deployed over the coming 5 years, which might be different in various sectors. A carbon tax for building is likely but also pilots of cap-and-trade (including Shanghai). Deployment of national cap-and-trade in various sectors will most likely take place -in particular Steel and Cement- while trying to keep CDM cash influx in sectors already covered (wind, solar, hydro). It is clear that Shanghai will be best placed to benefit form these measures in taking a lead towards a modernized urban (and industrial) economy, and that several lobbies are pushing for this.

Best practices

i. Shanghai has launched its own market place related to environment-related financial products in 2008. As no compulsory regulation is yet creating compliant-buyer demand in China, the Exchange aims at becoming a forum for stakeholders in GHG reduction projects -mainly through disintermediation and improved access to international markets. It also initiates domestic trading schemes related to Pollution Discharge Rights, starting with sulphur dioxide and chemical oxygen demand but aimed at expanding soon to CO2 under voluntary trade scheme in a pilot phase, targeting the Building
Sector.

ii. Shanghai Municipal Government implemented measures to make the public aware of the problems of energy efficiency and energy conservation. Shanghai Energy Conservation Supervision Center (SECSC), which is the first non-profit energy conservation administrative organization in China, affiliated to Shanghai Economic Commission, took an active part in the dissemination of energy conservation information, good case studies, technological consultation and energy conservation popularization and training. Shanghai was pioneer in this public education process.

iii. Public transportation has been a key area of efforts, with an active extension of underground lines so far, and ambitious plans to be a major actor in the national plan of launching China as the first market for green/electric cars. Shanghai’s advantage is to host the JVs between General Motors and SAIC, the largest car and utility vehicle maker in the country.

Introduction

Shanghai stands out within the Global and Chinese urban scenario, with a dense urbanization that anyway gives scope for lesser energy intensity than cities with greater urban sprawl in North America and with a modernized set of infrastructure and very effective urban governance that has a lead on its neighboring region.

Shanghai has recently shown what is maybe the most dynamic in the world underground/metro development of public transports and now wishes to promote electric vehicles' use as well as industry. It sees and projects itself as an Economic metropolis with the lead over a region on the verge to become a economic Megapolis. Shanghai is keen on developing tertiary and finance but won't give up on its industrial hand especially heavy industry (oil, steel, car) and their industrial districts (chemistry, mechanics, auto parts etc.) and harbor and logistics activities. In the Chinese institutional context, the Municipality of Shanghai operates as a true Government Shanghai with a clearly stated aim at remaining as much as possible politically, economically and financially independent. The Metropolitan area wishes to have a hold on its energy, matter and financial inbound and outbound flows. It wishes to accumulate and localize within its boundaries technological and intellectual knowhow, including a node of academic excellence in environment, positioning itself in global networks and ready to face the rising competition on knowledge and know-how within China (Beijing, Tianjin, Xiamen).

It projects itself as a laboratory for low carbon projects and models; Shanghai wishes to set the trend and standards and appropriate the new business models. It is thus at the center of debates on low carbon economy: ranging from the greening of roofs, development of ecozones (attempts prior to develop the ecological island of Chongming-Dongtan – the project has not matured but has started building the city's experience), current attempts at fostering international cooperation on urban and land use planning, to working at soon housing a prime carbon credits exchange.

Some success stories might set trends that can be translated to large and secondary cities in China; some particulars will remain Shanghai's privilege: a long history of 'economic capital' and the courtyard of exporting provinces that early benefited from opening reforms, a geography granted with river ways that ease its recourse to freight among others. Adding air capacities the city is a hub for transportation and logistics that polarizes a large part of Chinese most economic area. The latest developments tend to indicate that Shanghai urban area will be more and more integrated within a broader Yangtse Delta Region progressively forming a homogenous Megapolis spearheaded by the Shanghai Municipality.

1. Data

Demographics, economics and city shape

Background

China has urbanized about 300 million people within the last 30 years and is likely to urbanize as many in the coming 30. The process is characterized by a very low level of informal settlement and a strictly planned development.

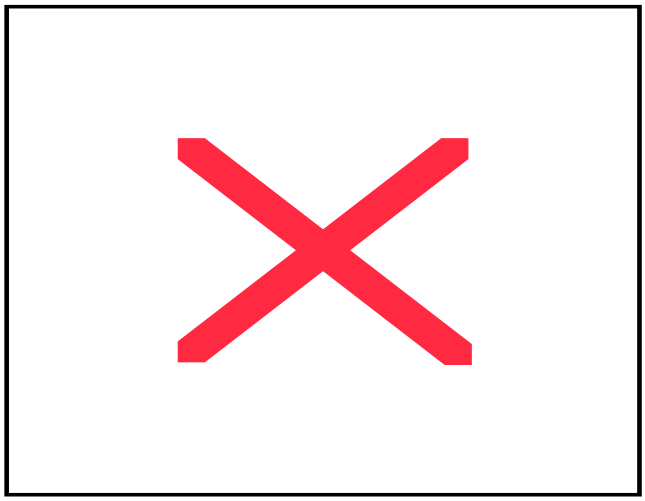


Figure 1 China urban growth forecast (Department of Economic and Social Affairs of the United Nations Secretariat, 2006)

In the process, urbanized population saw their living standards grow steadily over the years generating an increased burden for cities to sustain. Shanghai is of course reflecting the global trend but with the specificity of being one of the only completely modern megacities of China with an economical pattern that has still many heavy industries but that now also emphasizes further developing additional specializations in high technologies and services.

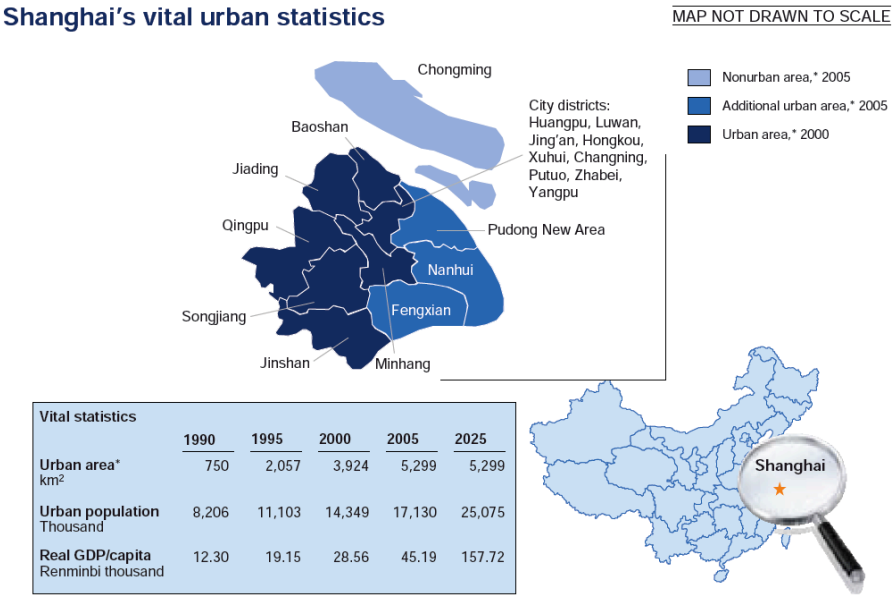


Figure 2 Shanghai's vital urban statistics (McKinsey Global Institute, 2009)

As many other Chinese cities, Shanghai is under fast urban growth process since the beginning of the "opening" policy in the 1980's. Shanghai is a Municipality administratively equal to a Province and is divided into 18 county-level divisions, with a population reaching 18,5 million people in 2009 and an overall urban area of 5300 km² and a density of 2600 hab/km².

Population growth

Migration (both from rural and other cities) is the principal engine of population growth in Shanghai as in many dynamic urban centers in developing economies –but in contrast to neighbor India where megacities have a greater natural growth than migratory accrual. China however presents a worth noting specificity in terms of rural migration control (see Hukou system).

The Hukou System.

The Hukou stands for the internal passport delivered to Chinese families which specifies the area of living as well as their urban or rural status. Since 1980, families are authorized to move to new places but with restricted access to certain services (education, healthcare, subsidies…). This makes an important share of migrants a "floating population" which status remains unclear until they get an official local urban Hukou. Meanwhile urban population census should be considered with precaution as it is difficult to know who is accounted for (local urban hukous, local rural hukous living in urban areas, non-hukou living in urban areas…). Uncertainties regarding interpretations of different statistics could thus be as high as 25%. Recent trends indicate that Hukou system is progressively losing its strength. Cities like Shanghai use it now as a way to select its migrants favoring most capable professionals.

The assessment the most consistent with international urban census criteria we found is from MGI, 2009. According to MGI criteria, migrants flow to shanghai was of 1.8 Millions between 2000 and 2005 which accounts for 64% of total urban growth. Natural growth is slightly negative: between -0.1‰ to -3‰ from years 2000 to 2008[2], mostly due to the enforcement of the national single child policy. Remaining increase of population comes mostly from spatial expansion of Shanghai urban area.

Economy

Shanghai was one of the first coastal cities to open to foreign investment in 1984. Economic investment was then boosted by the creation of Pudong new development area in the 1990's across the River, which had till then remained rural. The city has recorded a double-digit growth for 15 consecutive years since 1992 and in 2008 Shanghai's nominal GDP still posted a 9.7% growth to 1.37 trillion RMB. Shanghai's share in national GDP is now of 4,5%. 60% of overall workforce is now allocated to the tertiary sector, 38% in industry, and 4% in agriculture[3]. There is a strong political trend to bring heavy industry away from the municipality and replace it by high-tech/high added value manufacturing. The strategic situation of the city on the Yangtse Delta made it the first port of China with 25% of the whole country's import-export activity.

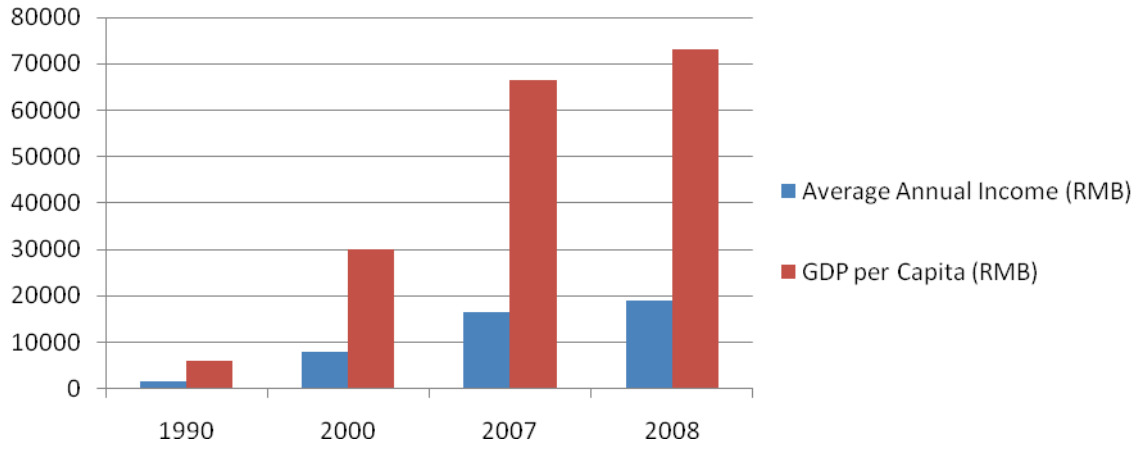


Figure 3 Comparison of Average Annual income and GDP per capita in Shanghai (Shanghai Statistical Yearbook 2009)

Shanghai industrial context and high rate of manufacturing produce important difference between the income and the GDP per capita, that is four times higher than the income.

City Shape

The municipality has been following different policies in terms of development trends such as a move towards decentralization and de-concentration of population in the city center to the

[2] Shanghai Statistical yearbook 2008
[3] Shanghai Statistical yearbook 2008 and MGI, 2009

benefit of new urban nods in peripheral counties, generating a polycentric metropolitan system. The city tripled its area in the past 25 years and is still growing.

Shanghai (Lianyang), residential area

Built-up area density = 14%

FAR = 1.2

Buildings height = 1 to 30 floors

Figure 4 Example of new High Rise development in Shanghai with relatively low density
(CSTB, Laboratory of Urban Morphologies) FAR: Floor-Area Ratio. In that case, FAR is lower than in traditional districts.

The core of the city presents a high density superior to 40,000 inhabitants/sqkm whereas the whole metropolitan area has a density of 2,600 inhabitants/sqkm[4] (as a reference, some provinces in China can reach a level of 1,000 inhabitants/sqkm in average, cities and rural areas combined). Mixed land use is also encouraged and limiting sprawl is a priority. However tremendous population growth added to an increase of individual living area from around 17m²/pers up to 30m²/pers today implies an unavoidable extensive territorial expansion. The new trends of developments with widespread high-rise residential towers might also be arguable in terms of real density, road network efficiency and land use intensity.

The latest developments tend to indicate that Shanghai urban area will be more and more integrated within a broader Yangtse Delta Region progressively forming a homogenous megapolis led by Shanghai Municipality.

Energy

General considerations

China: an energy consuming development

All over the country, economic growth and increase of consumption linked with urbanization generate acute challenges in terms of energy supply. Power generation illustrates well the trend: China has about 1,000 GW of installed power today and some 100 GW additionally installed every year.

Chinese cities energy consumption profiles are strongly industry oriented as shown in figure 5 below. Most of Chinese large cities are intimately related to some industrial activities which shall appear in their energy consumption profile.

[4] (Haixiao, Jian, & Bing, Mobility for development, 2008)

Figure 5 Share of industrial and urban energy consumptions

The country energy mix is clearly linked with its national natural resource: namely coal. Figures 6 and 7 give primary energy mix and electricity mix with still 80% of electricity produced by coal fired thermal plants and nearly 66% of its total primary energy.

Figure 7 Total primary energy supply mix of China (IEA,2007)

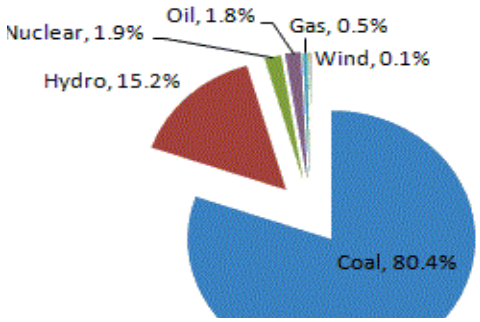


Figure 6 Electricity mix in China (IEA, 2006)

Shanghai: a modern megacity profile

Shanghai presents a steady growth of energy consumption, reflecting the on-going urbanization/economical development processes as well as a strong industry presence.

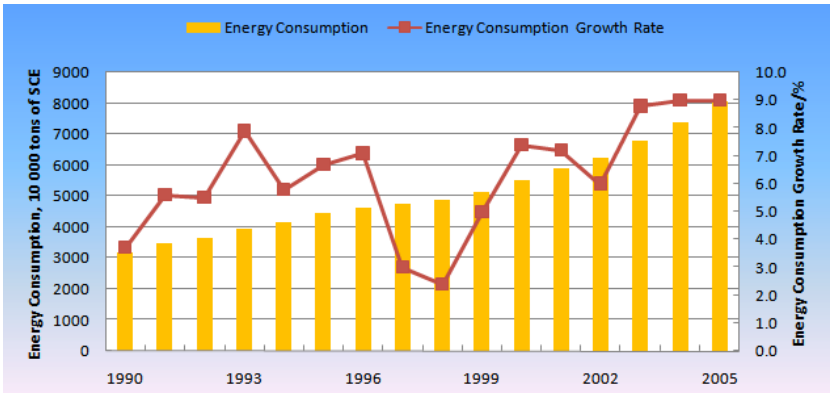


Figure 8 Energy consumption and growth rate in Shanghai (1990-2005) (Niu & Al, CO2 Emission Reduction in Shanghai:Responding to Climate Change Mitigation, 2009)

The energy supply mix of the city is also composed of coal, but in a much lower proportion than at the national level. Oil represents an important part of the mix, increasing over the years in order to equal the percentage of coal as supply primary energy. This is linked with Shanghai's rapid rise in vehicle ownership. Even if oil's carbon emissions coefficient is lower than the one of coal, an increasing share in the huge amount of city vehicles has not only put pressure on carbon emissions but also on the air quality in Shanghai downtown. Natural Gas contribution is minor but increasing, as well as the electricity coming from other sources, reflecting the increase of cleaner sources.

Coal imported to Shanghai comes from inland regions, mainly Shanxi, Inner Mongolia, Shaanxi, Ningxia in the North and Guizhou in the South West. Shanghai can import some of its coal through the Huangpu and Yangtze river mouth waterways. This is unlike most of the cities without developed waterways which have to rely on rail freight (Wehrle, 2008)

		1990		2000		2005		2007	
		Data	%	Data	%	Data	%	Data	%
Supply	Coal (10^4 t)	2633	58.9	4496	58.5	5324	52.5	5796	42.4
	Oil (10^4 t)	776	34.7	1238	32.2	1967	36.4	2853	41.7
	Natural Gas (10^8 m3)	-	-	2.5	0.6	18.7	3.1	29.7	3.7
	Electricity from other sources (10^8 kWh)					181	7.7	330	11
Consumption	Total consumption (10^4 tce)	3191		5492		8069		9767	
	Industrial consumption used (10^4 tce)	2370	74.3	3506	63.8	4558	56.5		

Figure 9 Shanghai primary energy mix evolution and secondary industry final consumption decrease (Liang Zhaohui, 2009)

Shanghai Municipal Electric Power Company (SMEPC) has been able to deliver up to 21 GW of electricity in 2008. SMEPC is proud of its power reliability rate, which lies at 99.982 percent. A 10 percent growth in electricity demand in the Shanghai area is foreseen, higher than the China-wide prediction of the IAE, which expects power supply and demand to increase with an average of 7.8 percent until 2015. SMEPC expects the Shanghai's needs to stabilize at 44 GW, out of which 20 GW will be produced in the Municipality of Shanghai. More than two thirds of the electricity consumed in Shanghai is also produced in the Shanghai Municipality. Thus, out of the 21 GW needed in peak seasons, 14 GW can be produced in Shanghai. The remaining 8 GW are imported from other provinces especially the Three Gorges Dam in Hubei, which provided 4.2 GW in 2007. In fact, the Three Gorges dam will be able to deliver a capacity of 18.2 GW after completion. Shanghai is interested in importing more hydropower – which is considered as a renewable and clean energy – to reduce its controversial high share of coal-generated power (Wehrle, 2008).

Regarding Gas, the IEA estimates that natural gas demand has been increasing by an average of 6.4 percent in recent years. This figure is even higher for residential areas, where it lies at 10 percent. The region of Shanghai was composed of around 5 million natural gas consumers at the beginning of 2007. Both households and industries consume more than 2.7 bcm (billion cubic meters) per year. Following the overall China trend, consumption for Shanghai is bound to reach 6 to 7 bcm in 2010 and foreseen to reach 12 bcm in 2015. Chinese government pushes for the extension of the domestic natural gas network as it is considered a cleaner energy. The number of urban residents with access to gas more than doubled in the last five years, the coastal areas accounting for more than half of this growth. The Shanghai region relies more on offshore extracted natural gas (platform in the China

Sea) and transported from Xinjiang Province. Most of Shanghai's natural gas is distributed by the company Shenergy, that owns a 95 percent market share in natural gas pipeline distribution. While some areas in Shanghai can be delivered with pipelines, remote areas have to rely on gas cylinders. Unfortunately, China's domestic natural gas production does not suffice to cover the demand on the Chinese market. Hence, China is now investing in building capacities to import Liquefied Natural Gas (LNG). For Shanghai, a special LNG regasification terminal has been built at the Yangshan deep water port to allow Shanghai an import capacity of 1.65 million tons of LNG starting from 2009 (Wehrle, 2008).

The city is already on the way of decreasing the relative part of its industrial consumption and its profile should get more and more similar to one of a developed mega city, keeping in mind that it wants however to retain key capital-intensive industries of national interests and domestic markets such as steel, car, oil refining. Government measures have been taken to control export oriented heavy industry and to help expand the service sector, both domestic and export-oriented. Indeed, the IEA estimates that energy use for the production of export goods accounts for one fourth of Chinese energy demand. Hence, this move is particularly relevant for export-oriented coastal regions like Shanghai, Jiangsu, Zhejiang and Guangdong which account for 70 percent of China's exports. From 74,3% for the industrial sector (the secondary industry) in 1990, it decreased to 56.5% in 2005. This relative decrease is correlated with the increase of the tertiary industry, as illustrated in figure 10.

Figure 10 Contribution of industries to end-use energy consumption in Shanghai (1980- 2005) (Niu & Al, CO2 Emission Reduction in Shanghai:Responding to Climate Change Mitigation, 2009))

The power generation in 2007 was of 74 billion kWh and the power consumption of 107 billion kWh. Overall energy consumption was of 98 million tons of coal equivalent in 2008 (3.5 % of China Energy Consumption).

Within the different climate zones of China, ranging from severe cold in Northern China to hot summer and warm winter in Southern China, Shanghai is located in the “Hot Summer and Cold Winter”. It is worth noting that, south of the Yangtze River, buildings do not integrate heating systems. The peak time for electricity consumption comes in summer with the massive usage of individual Air-Conditioner.

Generalization of air conditioner uses represents a growing burden on power supply in summer with peak loads getting more and more difficult to manage. It represented about 400MW on summer days in 1990 and was higher than 1200 MW in 2002[5]. Shanghai still faced shortages in 2009 during peak loads.

Regarding these peak loads, Chinese cities generally use gas-fired power plants for peak-load regulation since the start-up of gas-turbine is much faster than coal-fired power plants and more flexible in terms of operation (but more expensive). Huaneng Power group installed in Shanghai the first unit gas-fired power plant for peak hour grid regulation in 2006. It operates only in summer, when the demand is the highest. Shanghai also buys electricity at higher prices coming from the neighboring provinces

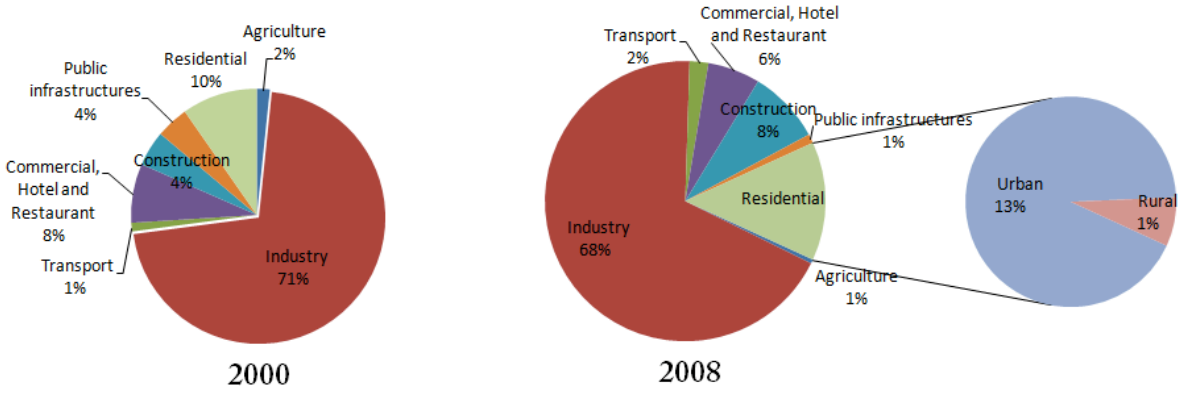


Figure 11 Shanghai electricity consumption by sector evolution (China Energy Yearbook 2008)

In 8 years, the repartition of electricity consumption by sector did not change radically, except for the construction sector that has doubled, as well as the transportation sector that remains minor. But it is important to note that the total power consumption more than doubled, from 56 TWh to 115 TWh used.

[5] (Long, zhong, & Zhang, 2004)

Shanghai Energy Efficiency

One of the main issues that Shanghai has to solve is its low energy efficiency in all sectors. The energy intensity in 2008 was 0.8 point (ton of SCE/ 10.000 RMB)[6], with a decrease of 3.8% regarding previous year. It is above national average which is 1.1 point for the same

year but with a lower decrease rate (-4.6%). Compared to other provinces and cities, Shanghai is one of the lowest decreases in 2008.

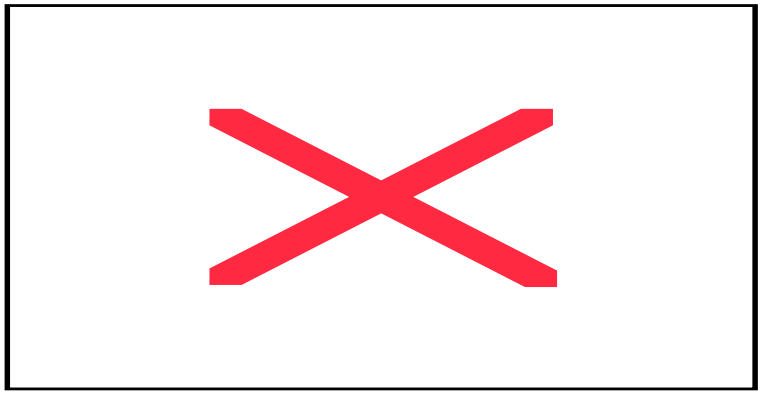


Figure 12 GDP and energy consumption per unit of GDP in Shanghai (1990-2005) (Niu & Al, CO2 Emission Reduction in Shanghai:Responding to Climate Change Mitigation, 2009)

The rate of increase in energy consumption (Figure 8) is lower than the rate of the economic growth (Figure 12). In fact energy consumption per GDP unit decreased dramatically during the past years. However, this gain in energy efficiency was not enough to compensate the fast economic growth.

The reduction of energy consumption achieved by improving energy efficiency did not stop additional energy demand. A good example is the power sector, which accounts for 53 percent of the energy demand's increase. Shanghai Municipal Power Company (SMEPC), Shanghai's dominant power supplier, expects electricity demand in Shanghai to grow at an average rate of 10 percent per annum over the next 10 years (Caroline Wehrle, 2008). The IEA, from its side, predicts that electricity consumption in China will increase 3.5-fold between 2005 and 2030

Sectors analysis

Residential

Shanghai residential energy consumption is growing quickly with the increase of Chinese living standards. Electricity now dominates households energy consumption.

Household electricity consumption was around 1618kWh/year/household in 2000 and raised to 2480 kWh/year/household in 2004[7], in which air-conditioning is around 776 kWh, or 31%

[6] Source : National Bureau of Statistics of China, Communiqué, 30 June 2009
[7] (Li, 2009)

of total consumption. This figure includes the space heating; Shanghai does not have district heating system like northern Chinese cities, people use individual reversed air-conditioning device for space heating in winter.

Figure 13 shows the evolution of Chinese households' access to key energy consuming devices and figure 14 displays the split of household electricity usage.

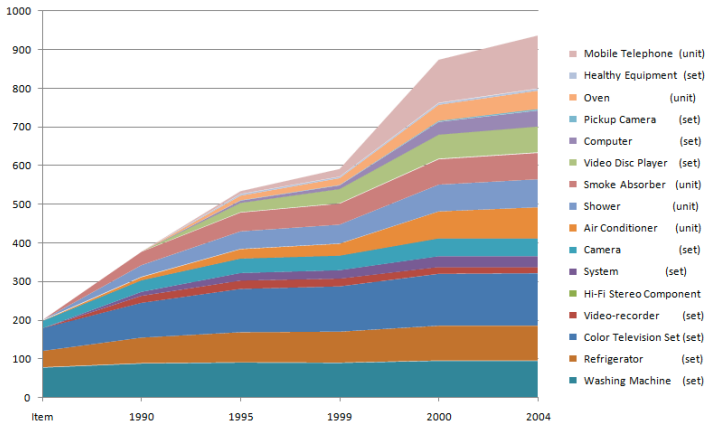


Figure 13 Trend of electric devices for 100 Chinese households (Statistical Yearbook China 2006)

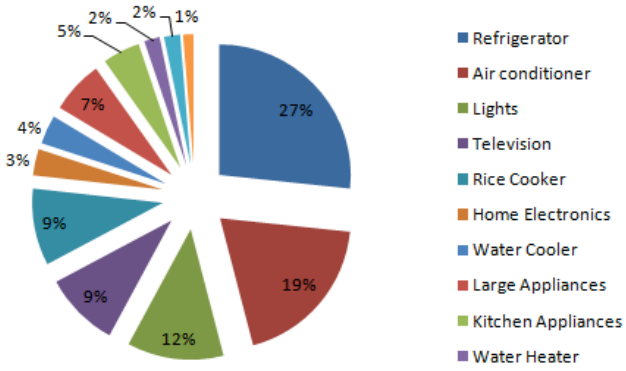


Figure 14: Composition of Shanghai household electricity consumption in 2000 (Brockett & al.)

Standby power alone may account for as much as 10% of total electricity use in Chinese households; however, actual standby use is highly influenced by Chinese residents' habit of unplugging these devices after use

The increase of living standards also impacts the per capita floor area jumping from 22 sqm in 2002 to 30sqm today and expected to reach 42sqm in 2030. Meanwhile, energy efficiency of residential buildings remains a domain with much progress to be done. Recent surveys revealed that more than 60% of new constructions did not meet energy efficiency standards whereas old housings energy oriented retrofits are very seldom.

Overall energy consumption for urban living has been almost multiplied by three in the past 30 years[8]. Nevertheless urban life energy consumption per capita just reached 0.54toe in

[8] Shanghai statistical report 2005

2008, an amount comparable to US levels in the mid 1950s. Annual growth of Urban Life energy consumption was 7.4% over the last decade in China[9]. The expenditure for energies is increasing over the years as shown in figure 15.

Figure 15 Evolution of Shanghai household residence expenditures in RMB (Shanghai Statistical Yearbook 2009)

However, energy price in China remains very low (due to heavy subvention from the State) with electricity being sold to end user at 0.5 RMB/kWh nowadays. As a consequence, the share of final electricity within the global household expenditures appears low (below 2%: figure 15 and figure 16).

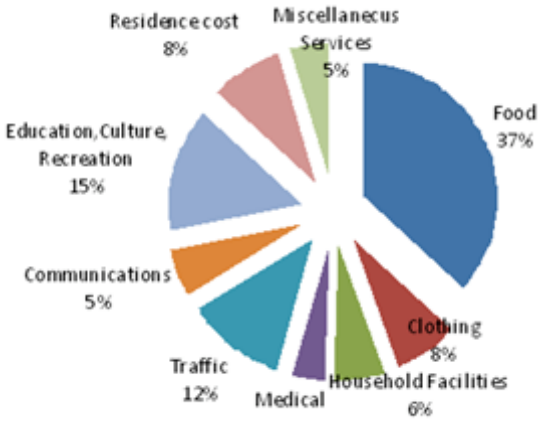


Figure 16 Average household expenditure per capita, 2008 (total= 19 500RMB) (Shanghai Statistical Yearbook 2009)

Commercial

In Shanghai as in any other cities, energy consumption of commercial buildings varies deeply among sectors. Shopping Malls are usually the most energy consuming due to energy greedy cooling needs to compensate high internal heat gains (people, lighting, devices…) and refrigeration.

[9] (CCICED, 2009)

Energy consumption is globally higher in summer while the consumption of energy during swing seasons evolves differently according to the building type. It is important to note that many shopping malls do not use free cooling during swing seasons.

Price of electricity for commercial buildings in Shanghai in 2010 are, according to the period of the day, of: 9.3 RMB/kWh at lowest and 1,1RMB/kWh at peak time.

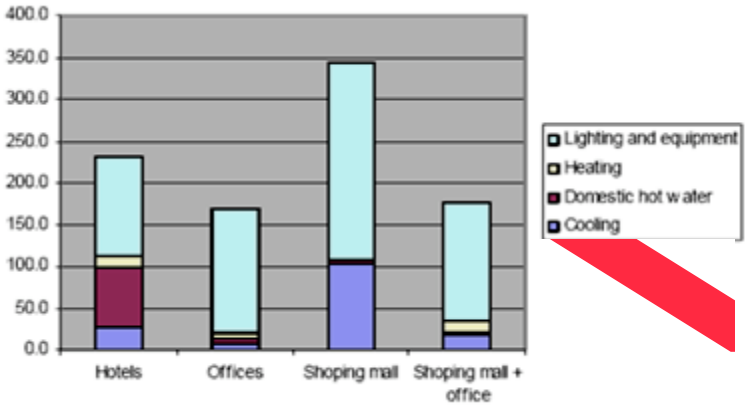


Figure 17 Energy consumption in different categories of commercial buildings in Shanghai Data in kWh/m²(Peng Xu, 2010)

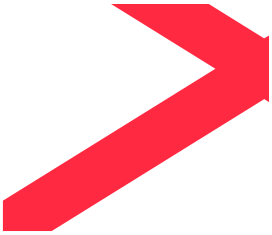


Figure 18 Monthly electricity Consumption (Peng Xu, 2010)

Transport: preserving soft modes, enhancing mass transit

During its recent development, Shanghai managed to maintain its high urban density and high mixed uses profile so that the share of soft and public transport modes remained relatively high. As for today over 50% of the people keep traveling by foot or bike.

Consistently with the rise of their living conditions and productivity Shanghai inhabitants are becoming more and more mobile seeing their overall traveling volume increasing both in number and length of trips. In 2004 the number of daily personal trips of Shanghai was about 41 million, up 45% over the figure of 1995, of which the number of trips by the permanent population was nearly 38 millions, and those by floating population nearly 3 million per day.[10]

From 1995 to 2004, the proportion of the motorized mode trips in Shanghai rose from 28% to 40%, of which the proportion of public transport rose from 20% to 24%, private motorized vehicle from 7% to 15%, while non-motorized-vehicle dropped from 42% to 28%[11]. In 2004, the total number of registered two-wheelers is 10.44 million, of which there are 9.37 million pedal bicycles, 0.84 million electric bicycles and 0.23 million LPG scooters. The daily trips by two-wheelers reached 12.9 million, in which there are 10.7 million pedal bicycle trips, a decrease of 3% compared to 2003, and 2.2 million trips made by electric bicycle and LPG powered scooter, an increase by 1.4 times.
It is worth noting that China exercises a very strong control of two wheels so as to avoid chaotic outbreak as seen in many other developing country. There were 640,000 registered motorcycles in Shanghai, in which 500,000 were light motorcycles.

The motorcycles account for about 55 percent of all vehicles, but only bear about 2.1 percent of the total transportation capacity. Because of the low level technology used for motorcycles,

[10]&[11] (Haixiao, Jian, & Bing, Mobility for development, 2008)

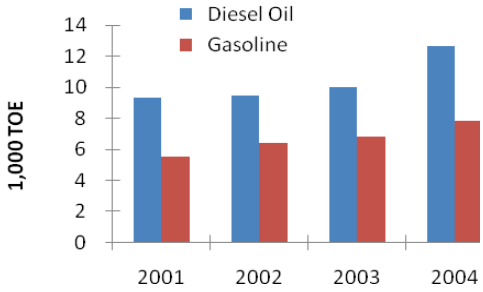
their emissions are quite high. The safety factor of motorcycle is the lowest of all types of vehicles and air pollution induced by motorcycles is serious.

In order to strengthen control of motorcycle use, the Shanghai government determined to prohibit the operation of two-wheel motorcycles (including light motorcycles) on main roads inside the circle line, five vehicle roads and some other regions. Meanwhile, the government enlarged the area where two-wheel motorcycles (including light motorcycles) with out-of-city licenses are prohibited, and set stringent penalties on the two-wheel motorcycles without licenses that are operating illegally.

Figure 19 Shanghai individual civil motor vehicles (2005 Annual Shanghai Statistics Report)

Obviously, rising access to motorized modes lead to important increase of fuel consumption as shown in figure 20.

Figure 20 Shanghai daily fuel consumption (2005 Annual Shanghai Statistics Report)



Congestion is now a major issue in Shanghai as offer of infrastructures fails to meet demand of trips. Government's strategy to develop a polycentric metropolis was not successful and the secondary cities in the suburbs did not manage to keep their new settlers. In the best case it generated important commutations worsening congestion in the end.

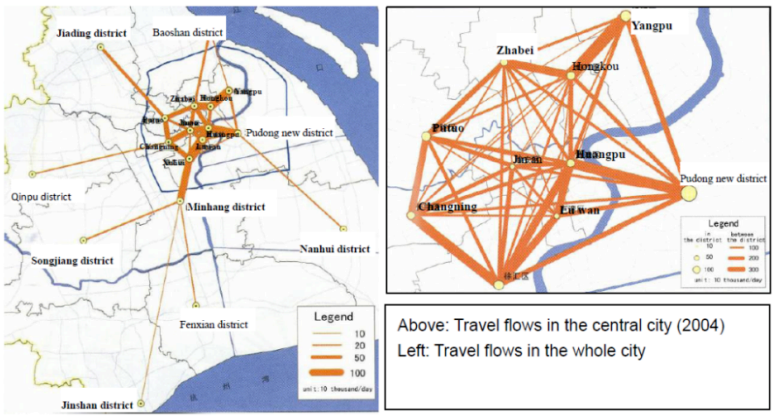
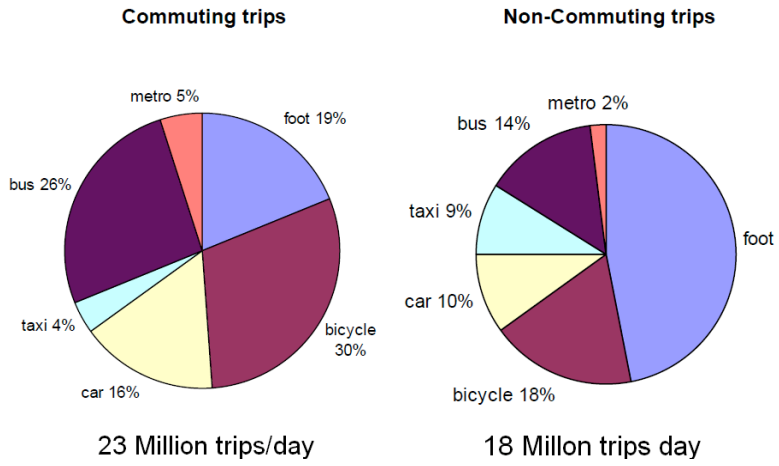


Figure 21 Travel flows in Shanghai metropolis and central city (Haixiao, Jian, & Bing, Mobility for development, 2008)

From 1995 to 2005 the average distance traveled increased from 4.5km/trip to 6.9km/trip. The number of commuting trips increased of 20% while non commuting trips increased of 100%; making it very difficult for public transport to match the new demand.

Figure 22 Mode splits by type of trips in 2006 (Haixiao, Jian, & Bing, Mobility for development, 2008)



From 1995 to 2006 the overall volume of travel in terms of passenger-kilometers increased

Year	Total Passenger -Kilometers	There into			
		Railway	Highway	Waterway	Airway
1995	17.098	3.418	0.823	3.171	9.686
2000	23.472	3.54	1.644	0.677	17.611
2005	66.393	4.886	7.506	0.452	53.548
2006	74.287	5.123	8.685	0.452	60.028

dramatically in all modes but waterways.

To meet the increasing demand, Shanghai developed its road system dramatically during the last ten years with per capita length and area of roads increasing respectively from 5.8km to 11,4km and 7.17sq.m to 16.54sq.m between 2000 and 2008.

The city made also tremendous efforts to generate a comprehensive public transportation system including a dense subway network to be finished around 2020.

Figure 23 Maps of Shanghai subway over the years (web)

Because of its strategic situation on the Yangtze River Delta, Shanghai is playing a central role in terms of logistics and transport of both passengers and freight at regional and national scale. This fact obviously shapes Shanghai transport system which can be felt with passengers transport figures and gets obvious with freight values (table 2).

Year	Total	Composition			
		Railway	Highway	Waterway	Airway
1995	436 210	41 660	245 730	148 450	370
1996	458 210	62 130	250 230	145 440	410
1997	459 380	58 170	259 910	140 820	480
1998	462 300	52 920	263 520	145 290	570
2000	501 620	32 630	283 690	184 420	880
2004	657 890	38 620	315 540	301 480	2 250
2005	713 040	38 410	326 840	345 570	2 220

Table 1 Cargo transport by various transport modes in the Shanghai region (unit: thousands of tons) (Shanghai statistical yearbook 2007)

The city is now developing major multimodal hubs such as Hongqiao airport or larger and better connected harbors facilities and industrial parks (such as SKIP in the southern area). One of the objectives would be to allow a shift from road to rail with better connections.

Industry: a sector intimately related to urban areas in China.

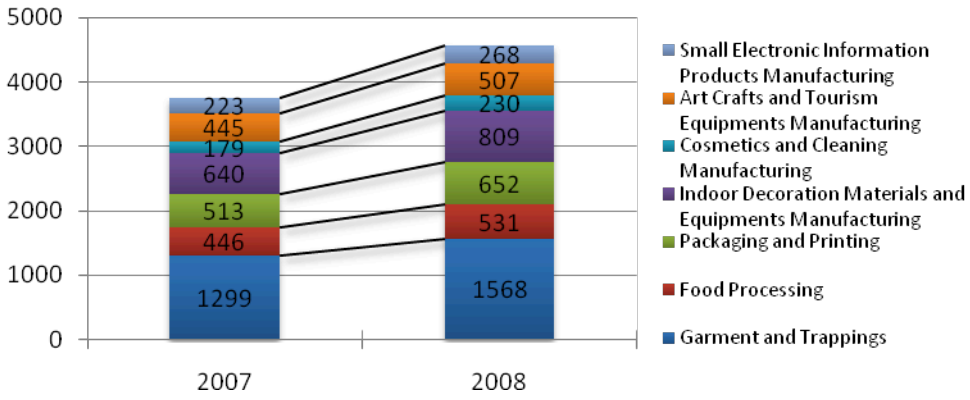


Figure 24 Evolution of Shanghai urban industries by sector (unit: number of enterprises)

(Shanghai Statistical Yearbook 2009)

Shanghai's energy profile is closely linked with its industrial activities and it is important to have some understanding of this sector.

Six key industries in Shanghai, represent 64% of Gross Output (2008): Manufacturing of Electronic Information Product, Automobile, Petrochemical and Fine Chemical Products, Speciality Steel, Equipment Complex and Bio-medicine.

Although it is widely stated that Shanghai industrial sector is currently shifting from heavy to high-tech industry, we found in our study that Heavy Industry is still gaining weight with a much faster trend compared to light industry.

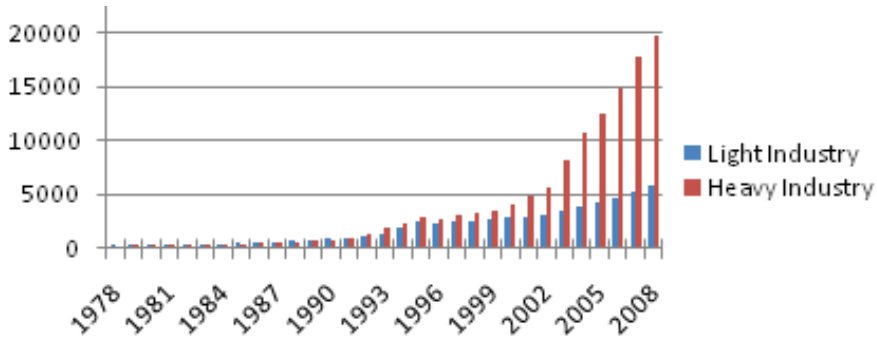


Figure 25 Evolution of light and heavy industries of Shanghai (Gross output value in 100 million RMB) (Shanghai Statistical Yearbook 2009)

	2005	2006	2007	2008
Information Chemical Product	6	9	10	11
Medical and Pharmaceutical Product	219	234	269	294
Aviation and Aircraft Manufaturing	16	22	29	31
Electron and Communicate Equipments	1326	1534	1810	2254
Electronic Computers and Office Equipments	2242	2429	3214	3149
Medical Treatment Instrument and Meter	192	231	272	303
Total High-tech industry Gross out put	4002	4460	5607	6042
% of high tech industry in total Ind. gross output	25,10%	24,40%	25,60%	24,80%

Table 2 Evolution of the share of high-tech industries in total gross output of Shanghai industry (unit: 100 million RMB) (Shanghai Statistical Yearbook 2009)

The industry sectors listed above are the one considered as high tech industries by the Shanghai Statistics Bureau. Even if High-tech industry gross output is rising over the years, it is not rising faster than other secondary industry sectors, and its share in the total secondary industry remained the same over the past five years.

GHG Emissions

Green House Gas (GHG) emissions in China

With its rapid growth of energy consumption and no dramatic changes in its energy mix, remaining mostly based on coal and other fossil fuels, China saw its GHG emissions increasing tremendously through the past decades. In 2006, China officially overtook United States in terms of total emissions with some 6.6 Gtons of CO2 equivalent emitted.

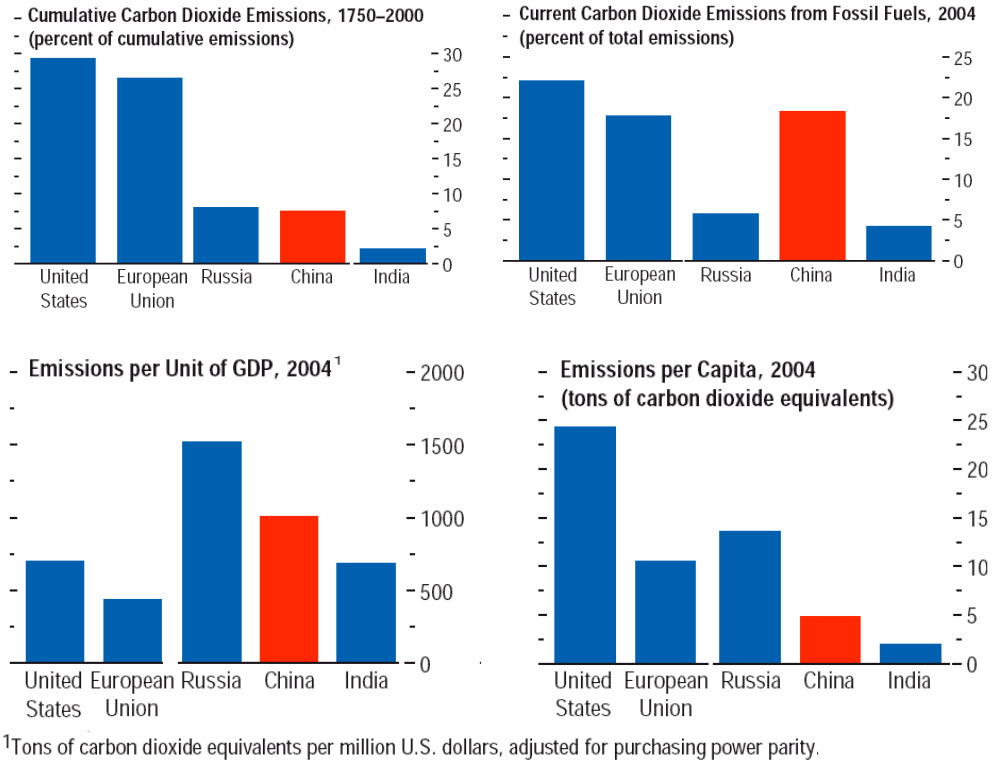


Figure 26 World Carbon dioxide emissions by country 1990-2030. IEA (2006,2007)

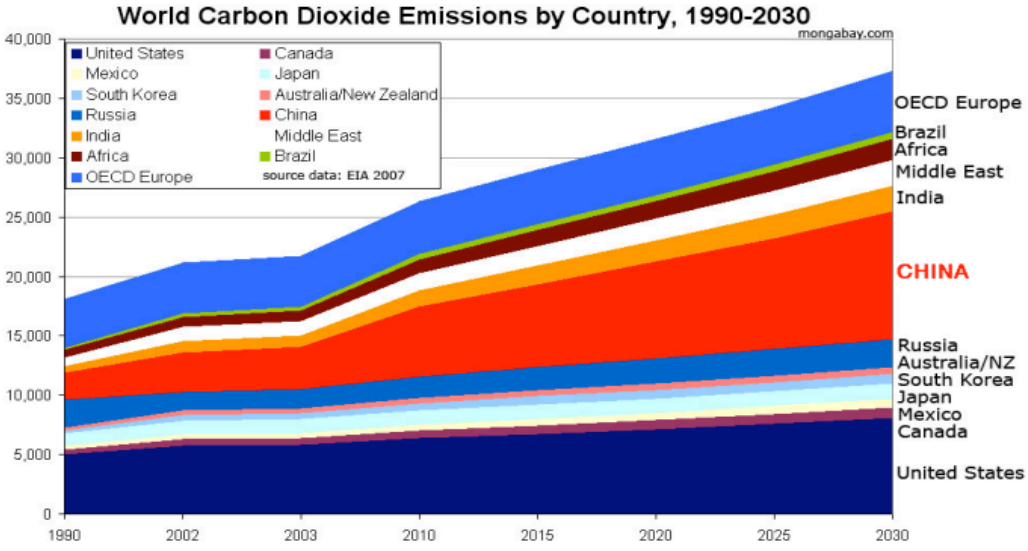


Figure 27 National carbon emissions evolution (past, present and future estimation) (unit: million metric tons) (Baumert, Herzog and Pershing (2005);)

China relies primarily on coal use, which has resulted in serious nationwide environmental problems. Coal-based energy supply has long been a top concern, and needs to be overhauled with the social and economic progress. SO2 emissions from coal combustion have long been a major contributor to ambient air pollution in Chinese cities and are the primary cause of acidic precipitation in ecologically sensitive areas and much of China's most fertile land areas.

China's total GHG emission in 2004 is about 6,100 Mt-CO2e (net emissions: 5,600 Mt-CO2e if deducting the part of carbon sink) with the following GHG gases share: CO2: 5,050 Mt ; CH4: 720 Mt-CO2e and N2O: 330 Mt-CO2e.

From 1994 to 2004, the annual average growth rate of GHG emissions was around 4%, and the share of CO2 in total GHG emissions increased from 76% to 83%.

China's GHG emissions still present very low per capita emissions in sharp contrast to the situation in developed/industrial countries, and well below the world average level. Additionally, the final allocation of a part of these emissions to China is certainly arguable as most of the industrial production is exported and final use is therefore out of national territory.

GHG emissions in Shanghai

Being both a major industrial basin of China and the most developed city of the country with fairly higher living standards than the average, Shanghai presents much higher GHG emissions than the rest of the country. It was 3 times higher in 2004 than the national value, and superior to most of European countries.

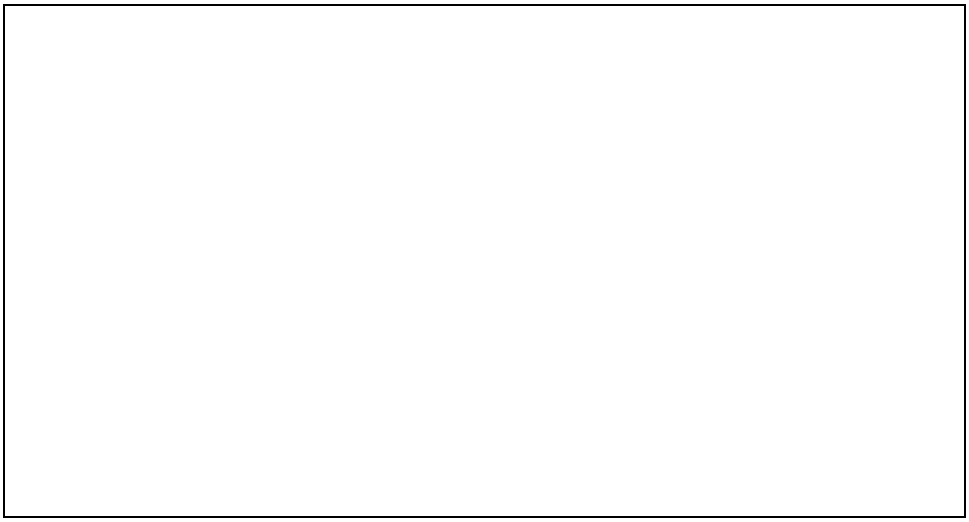


Figure 28 Per Capita GHG emissions in Shanghai figure: comparison of Shanghai per capita emissions with international averages (2004) (Niu & Al, CO2 Emission Reduction in Shanghai:Responding to Climate Change Mitigation, 2009)

The carbon emission per capita in Shanghai in 1990 was much lower than that in developed countries but the situation displayed in this 2004 chart is very serious, with Shanghai putting up high values, highlighting the fact that Shanghai carbon emission control and politics were not as effective as those of developed countries.

Important efforts were made to reduce GHG emissions at municipal level. As a consequence the GHG intensity of the economical development was fairly reduced. However the economic growth was higher and accelerating faster so that in the GHG emissions kept growing in an exponential way (see figure…).

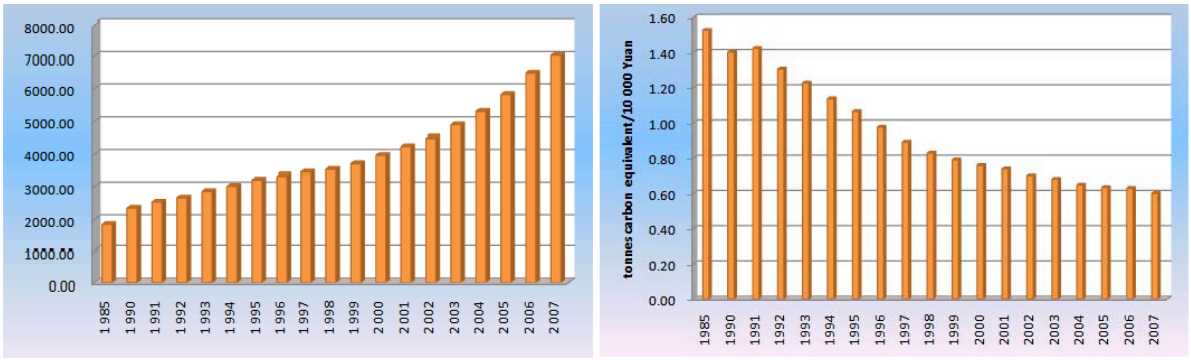


Figure 29 Figure: Left: Total GHG emissions in Shanghai (tons of Carbon equivalent); Right: GHG intensity of Shanghai economy (tCeq/10000RMB) (Niu & Al, CO2 Emission Reduction in Shanghai:Responding to Climate Change Mitigation, 2009)

The carbon emission in Shanghai raised whereas carbon emission per unit GDP dropped, showing improvement of energy efficiency but not sufficient to compensate rapid growth.

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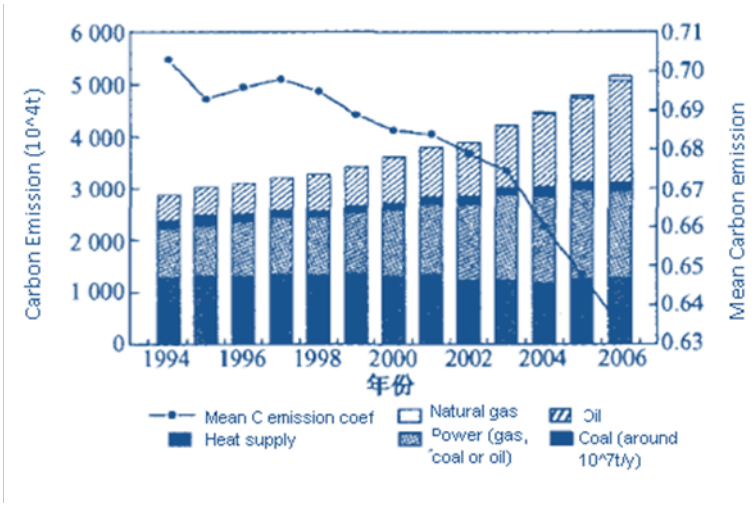

Figure 30 Carbon emission structure of different types of energy consumption in Shanghai, and mean carbon emission coefficient (ZHAO Min & al, August 2009)

Regarding the energy sources of these GHG in Shanghai, the above table provides the carbon emission structure: Power and heat supply are generated mainly from coal, the sum of these emissions plus those of the coal consumed in industrial processes highlight the predominance of this primary energy in the total emissions. Oil also represents a main contributor to the city emissions with the fastest growing trend over the years. Alternative technologies such as wind power, hydropower, and alternative fuels have to be developed to stabilize the trend and reverse the oil growth.

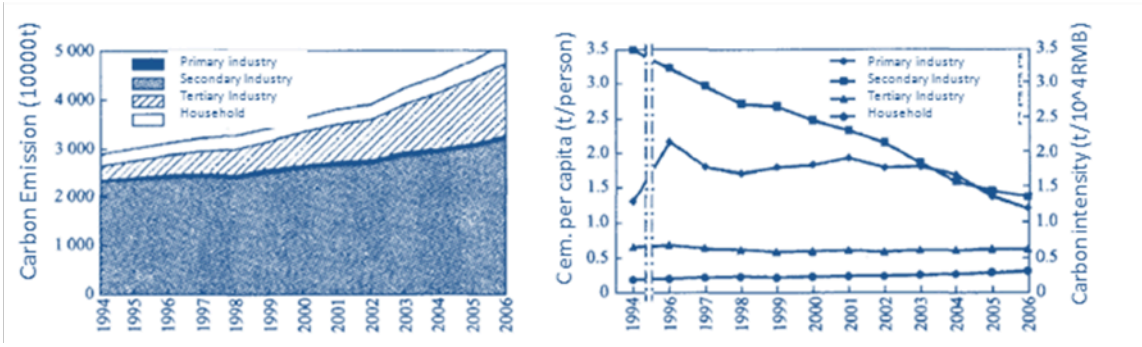

Figure 31 Carbon emissions and carbon intensity of different sectors in Shanghai (Min & al, 2009)

According to this figure, there is a small carbon intensity decline for the secondary industry due both to the improvement of the energy efficiency of many industries which reduced their energy consumption per unit of product; and also from the optimization of the industry structure thanks to the shutdown and transfer of energy-intensive enterprises out of Shanghai, as well as the increase of low energy consumption manufacturing industries (such as electronics, machinery …)

The tertiary sector raise on the left chart is mainly due to the rapid growth of transportation, storage and telecommunications industries, and the consequent need of oil consumption. The tertiary sector is the core of Shanghai's future economic growth: its development will focus more and more on finance, insurance, logistics and other services with small carbon intensity.

2. Policies

National energy plans and policies.

Climate Change has drawn the attention of the world since the signing of “United Nations Framework Convention on Climate Change” (UNFCCC) and “Kyoto Protocol”. Then the completion of “IPCC Fourth Assessment Report” (AR4) in 2007 made it become a hotspot. China also pays more and more attention on this issue. China has ratified **Kyoto Protocol** with no binding commitments. However central government released a set of comprehensive and ambitious plans and programs aiming at reducing GHG emissions and enhancing energy efficiency and supply independency.

The 11th five year plan (2006-2010) provides main Guidelines for securing economic growth and economic structure, urbanizing the population, conserving energy and national resources, encouraging environmental practices, and improving education. In this framework, the **China National Climate Change Program** (CNCCP) was launched in 2007 setting up strategic goals and specifying the guidance to the whole country, providing guidelines to local governments and industries to develop plans and programs, identifying guidance and tasks sector by sector. It was followed by a White Paper in 2008. The plan does not include targets

for carbon dioxide emission reductions, but it has been estimated that, if fully implemented, China's annual emissions of greenhouse gases would be reduced by 1.5 billion tons of carbon dioxide equivalent by 2010 (source : China issues first national plan to address climate change, Xinhua News Agency, published 2007-06-04).

The **White Paper: China's Policies and Actions for Addressing Climate Change** not only reaffirmed the guidelines, objectives and basic principles etc. but also introduced the progress and achievements through the implementation of CNCCP. It is mentioned in the part named "Policies and Actions to Decelerate Climate Change" that "China has adopted proactive policies and taken active actions to slow the process of climate change. It has adopted a number of policies and measures to adjust the economic structure, change the development patterns, save energy and raise the efficiency of energy use, and optimize energy mix and promote afforestation. Marked achievements have been made. " (White Paper, 2008) This shows that China's emission reduction is mainly carried out over the energy resources.

The Renewable Energy Law entered into effect in January 2006. The law stipulates the connection of renewable energy sources to the grid and the integration of renewable energy in public buildings. According to the Renewable Energy Law, the MOHURD (Ministry of Housing and Urban Development) is obliged to develop technical standards for renewable energy technology such as solar water heaters and heat pumps. Also in the 11th five year period, the Work Plan for **Energy Conservation and Pollutant Discharge reduction** was launched, detailing the measures and actions to be undertaken nationwide. It aimed at cutting energy consumption per unit of gross domestic product by 20% over the course of the 11th five-year plan, as well as cutting the discharge of major pollutants by 10%. The plan was issued in 2007 after the 4% reduction in energy intensity targeted for 2006 was missed, and all companies and local and national government have been asked to submit detailed plans for compliance before June 2007. In 2006 the reduction achieved was 1.23%. The implementation of such plan involved a variety of measures, including increased use of renewable energy, revised pricing for primary energy sources and electricity, export restrictions on energy intensive and highly polluting products, and tax incentives for pollution-reduction projects. Energy efficiency in Buildings is also one key area in the amendment, with the determination of penalties for non-compliance with buildings standards. Energy-saving Management Regulation of Residential Building (2006) and other laws were implemented, however design of policies and measures, varies largely between the different climate zones. The fulfillment of energy conservation targets is from this date taken into consideration when evaluating the performance of local government officials, who consequently warned that violating energy conservation and environmental protection laws will lead to criminal proceedings.

Top-1000 Energy-Consuming Enterprises program launched in 2006 has set energy-saving targets for China's 1000 highest energy-consuming enterprises. The implementation plan provide guidance to the enterprises to significantly improve their energy efficiency with the goal that their energy intensity reach the level of advanced domestic or international industries, and could contribute to somewhere between 10% and 30% of the savings required to support China's efforts to meet a 20% reduction in energy use per unit of GDP by 2010. The Chinese government has imposed even stronger enforcements to shut down those small-capacity coal-fired inefficient, and in some cases, even put teeth into law for removing heavy polluters, backward, obsolete production capacity mainly for cement, steel

and iron industries. By small capacity units, it here means Unit capacity ≤ 50MW, to Unit set ≤ 100MW with a 20-year operation, as well as unit sets with coal intensity higher than the provincial average level by 10% or national average by 15%. As a result, in 2006: 3.1GW were closed, 14,4 GW in 2007 and the trend continued to go up (in 2008, from January to June, 8,4 GW). The largest number of these 1000 enterprises were located in the coastal area of the East Region (268 enterprises) where Shanghai (14 enterprises) as well as a number of more developed provinces are based. These enterprises can be classified in nine categories: Iron and steel, petroleum / petrochemicals, chemicals, power generation, non-ferrous metal, coal mining, construction material, paper and finally textiles.

On the top of this, a **Middle and Long Term Program of Renewable Energy Development**, issued by NDRC[11] in 2007, sets the target to increase the production of renewable energy to 10% of the national electricity mix by 2010 and up to 15% in 2020.

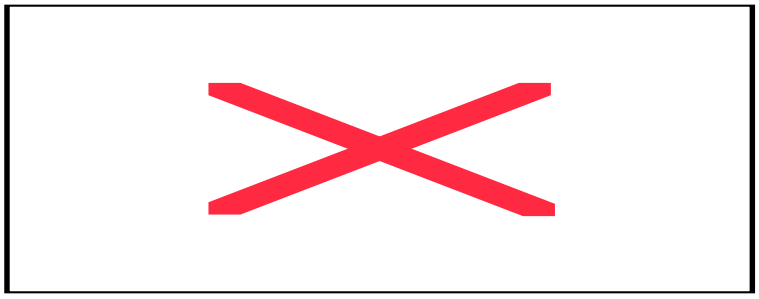

Table 3 Targets for renewable energy Power generation in china (GW)

The **12th five year plan** (2011-2015)**,** just signed in April 2010, fixed an objective of 45% reduction GHG emissions per GDP unit by 2020 compared to 2005 levels. Pilot low carbon cities projects are set up all over the country.

Local plans and policies

Organization of Shanghai Municipal Government (SHMG)

The Chinese central government dictates the laws and political guidelines, that have to be applied by the 23 provinces, the 5 autonomous regions, the 2 special administrative regions and the 4 municipalities (Shanghai is in this last range, with Beijing, Tianjin, and Chongqing).

SHMG has 1 government leader (Han Zheng) over Governments organs that are national government subsidies organs at local level, transcribing locally the national guidelines. There are other organizations directly under SHMG in order to proceed to implementation.

Each Sector has its municipal structure, implying different municipal organization, as you can see below with the example of Shanghai Urban Transport sector

[11] National Development and Reform Commission

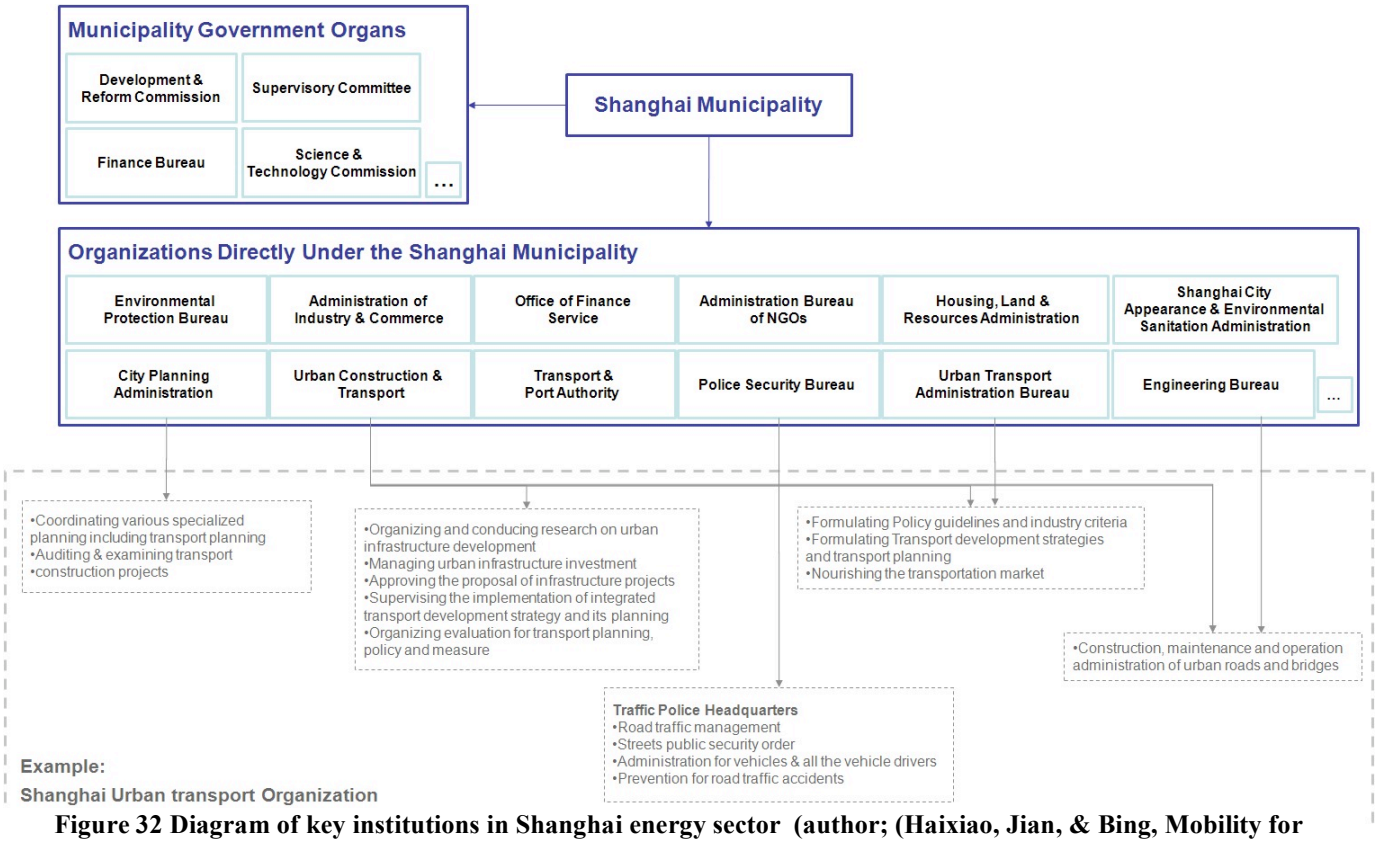

Figure 32 Diagram of key institutions in Shanghai energy sector (author; (Haixiao, Jian, & Bing, Mobility for development, 2008)

Energy Actions in Shanghai

In line with national regulations and policies, Shanghai government and organizations released a set of comprehensive texts related to energy management.

Table 4 Local policies on energy in Shanghai (Niu & Al, CO2 Emission Reduction in Shanghai:Responding to Climate Change Mitigation, 2009).
Note : SPCSC = Shanghai People's Congress Standing Committee

Shanghai strategy to reduce its energy challenges are divided in different categories:

- Develop renewable Energies
- Increase gas supply
- Improve energy efficiency, especially for industries, transports, constructions, new energies

Shanghai needs to reduce the proportion of coal in its energy structure as this primary energy source carbon emission factor is the highest. Even if the percentage of coal in the supply mix is decreasing (see figure XX table pink and blue XX), the number of tons increase quickly: from 26Mt in 1990, it has more than doubled in fifteen years to reach 58Mt. Therefore, control the coal growth is a challenge for the city, that can be reached thanks to improvement of the energy efficiency or radical action on coal-based industries

According to the 11th five year national plan, the energy consumption per unit of GDP in Shanghai shall be reduced by 20% by 2010. Subsequently, Shanghai decomposed the indicator among the industries and departments in the **Suggestion for Further Strengthening the Energy Conservation Work in Shanghai** (2006). In addition, Shanghai issued Shanghai Eleventh Five-Year Plan for **Energy Conservation**，with amended parts similar to the national ones, and **Implementation Plan for Energy Conservation and Emission Reduction in Shanghai** (2007) to further determine the targets for its municipality.

New Regulations effective from July 1, 2009, regarding rational utilization and energy conservation were ratified, for Energy Conservation in Industry, in Architecture, in Communications and Transportation, in Public Institutions and for Major Energy Users.

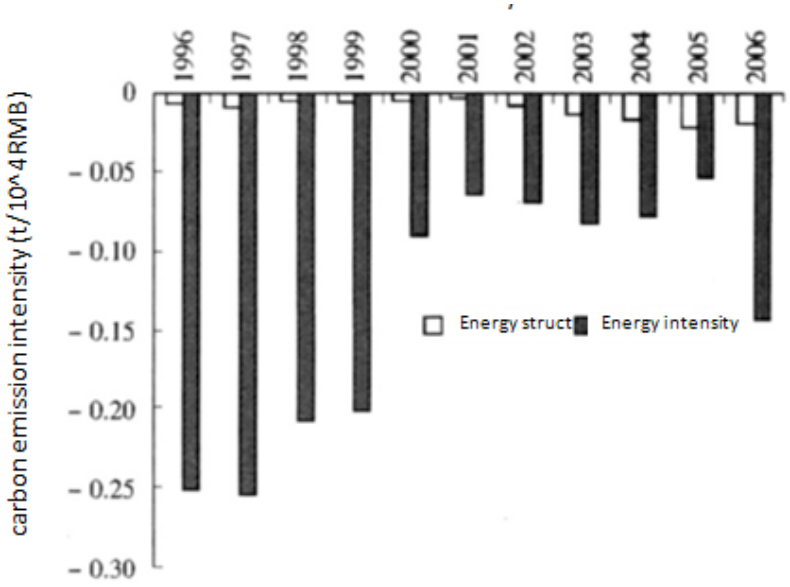

Figure 33 Contribution of energy structure and energy intensity to the carbon emissions intensity in Shanghai (China Academic Journal Electronic Publishing House, 2009)

Changes in Shanghai's carbon intensity were mainly due to changes in energy intensity. The overall energy structure adjustment that Shanghai is setting up from few years has an increased influence on the carbon emissions.

Capitalizing upon the leading position of China in Clean Development Mechanism projects under the Kyoto Protocol, Shanghai has launched its own market place related to environment-related financial products in 2008. As no compulsory regulation is yet creating compliant-buyer demand in China, the Exchange aims at becoming a forum for stakeholders in GHG reduction projects -mainly through disintermediation and improved access to international markets. It also initiates domestic trading schemes related to Pollution Discharge Rights, starting with sulphur dioxide and chemical oxygen demand but aimed at expanding soon to CO2 under voluntary trade scheme in a pilot phase, targeting the Building Sector. Further developments are likely under the Twelfth five-year plan.

SHMG also implemented measures to make the **public aware of the problems of energy efficiency and energy conservation**. Shanghai Energy Conservation Supervision Center (SECSC), which is the first non-profit energy conservation administrative organization in China, affiliated to Shanghai Economic Commission, took an active part in the dissemination of energy conservation information, good case studies, technological consultation and energy conservation popularization and training. Shanghai was pioneer in this public education process.

Sectoral Policies

Buildings

Shanghai Municipality committed in 2007 (in The Implementation Plan for Energy Conservation and Emission Reduction in Shanghai, 2007) to implement the standard that newly erected buildings shall follow a binding energy-saving 50 percent standard and would like to soon extend it to a 65 percent standard. Reaching the standard should be the precondition for getting a construction permit. With these measures, Shanghai expects to reach its building energy saving goal of 15 percent. Shanghai would also like to transform all public and government buildings into energy-saving buildings to give a good example to the construction industry. However, a study by the Chinese Ministry of Construction has shown that only 53 percent of the newly Chinese constructed buildings meet the set standards of energy efficiency. Although respecting energy-saving standards would only increase building costs by 5-10 percent, many real estate developers are unwilling to bear the costs, favoring short-term profits over long-term considerations.

Shanghai Energy-efficient Building Design Standards, adaptation of the national standard of the same name, encourage contractors to use energy-efficient materials and adopt energy-saving technologies for heating, cooling, ventilating, and lighting public buildings. In the respects of building energy conservation, eco-building is strongly promoted.

Despite rising interest in green building, however, across much of China developers are increasingly abandoning traditional building practices for more energy-intensive Western styles. The nation has also become a popular destination for the world's top architects to nestle their fantastic but often highly energy-consumptive masterworks. This trend could change according to the following event: A 71-story tower in Shanghai is expected to

become end 2010 the world's most energy-efficient tower on the road to its "zero" energy footprint goal. It is expected to consume 58% less energy than a tower following current energy codes, thanks to use of wind energy, internally ventilated double wall facade to limit heat absorption and act as insulation, radiant panels, light responsive automatic blinds and Photovoltaic (PV) panels. Shanghai ecology demonstration office building is also a good candidate to show the example: it is the winner of the 'Green Innovation Design Award' and the 'Top 10 Best Construction Achievement Award'. It uses 75 per cent less energy than comparable buildings. Twenty per cent of the total construction energy will be sourced from renewable energy.

Industries

The 2009 update of the Shanghai Energy Conservation push energy-conservation technology transformation in major energy-consuming industries such as electric power, iron and steel, petroleum processing, chemical engineering, building material and equipment manufacturing to raise the level of energy efficiency. It emphasize on the efficiency of electric motors, blowers, boilers, furnaces, pumps and other equipment, and promote the adoption of technologies such as combined generation of heat and electricity, utilization of afterheat and residual pressure, optimization of energy systems as well as advanced detection and control of energy consumption. It also push the Shanghai power-grid enterprises to sign grid-joining agreements and electricity purchase agreements with renewable energy power enterprises and provide these enterprises with on-grid services such as switching-on, measurement and settlement. Finally SHMG prohibits construction of coal- or oil-fired generator sets, or coal-fired thermal power sets that fail to conform to the national standard.

For example, Shanghai strictly implement national regulation on "list of phase out out-of-date technique and product" to promote the phase out of the high energy consuming, heavy polluted technique, equipment and production line (Suggestion for further Strengthening the Energy Conservation Work in Shanghai，2006）.

Transportation

As for communication and transportation, the priority strategy is to save energy from the transportation equipment and facilities (Eleventh five year plan on Shanghai communication, 2005)

Under the guidance of the central government, urban public transport in China has demonstrated innovation leaded by regional and urban government. Unlike other public enterprise, the public transport has its own features, therefore can create special policies in different cities. The 3-year action plan on prior developing city public transportation from 2007 to 2009 targeted that public transport passenger volume will represent 65% of the whole vehicles, and 33% of all transport modes. To reach this goal, the construction of public transport infrastructure had to be speed up, the public transport management and service level strongly enhanced (strength the supervision of the public transport company) and supporting policy of public transport development were set up with long term mechanisms or purchase by the government.

Vehicule License Plate auction policy is a key politic of Shanghai : Controlling the number of motorized vehicle has been a successful practice in Shanghai from the 1990s, keeping a balanced dynamic between road supplies and increasing vehicle demand by, for example, the license plate auction and parking policy. The licence plate auction was set in 1998 to 20 000 RMB for the car made in Shanghai, and 100 000 RMB for the other cars, to simulate local economy. From 2000, the policy has changed and all the car licenses are auction open, with a monthly adjustment. Since 2004, the government vehicle license has attended the auction.

	2000	2002	2004	2006	2007
Number of vehicle license (million)	1.4	3.2	7.2	6.5	7.75
Price of license (k RMB)	14.5	27.8	30.6	38.3	47.8

Table 5 Number of vehicle License in Shanghai and price (Huapu & Qizhi, 2009)

Renewable energies

The **Shanghai Green Electricity Scheme** offers electricity consumers in Shanghai the opportunity to "green" their electricity consumption by buying some amount of green electricity for which a premium needs to be paid. To improve the energy efficiency in Shanghai, the Shanghai government not only adopted macro-control policies to address energy issues but also promote energy conservation idea from public awareness. The Shanghai experience shows that it is important to keep the local residence aware of the problem of energy conservation and environment pressures. The public awareness makes it possible to meet the energy and environment challenge through the joint effort of the whole society.

Shanghai Municipality would like to reach a wind power installed capacity of 200-300 MW in 2010. Space is limited in the Shanghai municipality and only allows three wind parks (Fengxian, Nanhui and Chongming) to produce a total of 24.4 MW. Nevertheless, offshore wind farms bear a higher potential for Shanghai: 100 MW of offshore wind capacity are planned by 2009/2010 in Donghai. Scientists estimate that offshore wind energy potential could be up to three times as high as onshore potential. For solar energy, the target of Shanghai Municipality is to reach a production of 10 MW until 2010. Shanghai's power companies are also now financing nuclear power plant projects in nearby provinces. One illustration is the Qinshan nuclear power plant in Zhejiang province, which disposes of two 650 MW reactors and is planning two more 700 MW reactors. Shenergy, who has invested in this power company, will be able to import 1000 MW to Shanghai for distribution. (Wehrle, 2008)

According to The Eleventh Five-Year Plan of Shanghai Municipality for Energy Sources Development, however, the renewable energies consumption in Shanghai is expected to reach only 0.5% of projected total energy consumption, far lower than the target as set in Renewable Energy Development Plan. Therefore, there is huge potential for the development of renewable energy in Shanghai (UNEP-Tongji).

3. Road Maps

Roadmaps so-to-speak are at the crossroads. It is expected that, in line with the next Five-Year Plan, a lot might be announced at the end of year 2010. Until then many subjects are hotly debated within the planning authorities of Shanghai Municipality. If some elements of it transpire, at the time of writing we feel one can safely (i) recall the opportunity that the Universal Exhibition represented to showcase some of the pilot project underway, (ii) recall some key recommendations from the blueprints that appear from Tongji University –a leading university in Shanghai, it is quite close to urban planners and policy-makers, se well as (iii) indicate the perceived elements of the current debate.

As Shanghai hosts World Exposition 2010 under the slogan "Better City Better Life", there is a great opportunity to put further forward the city's deep engagement for a sustainable low carbon urban future.

3.1. The Expo and current pilots

Shanghai 2010: Better city Better Life.

What better way to express Shanghai's present will to move towards urban sustainability than the World exhibition which the city hosts in 2010 dedicated to urban life's improvement and which is anticipated to be the largest event of this kind ever?

The whole event will last six months and is expected to host up to 70 million visitors introducing new means of transport, building energy efficiency among many other "best urban practices". Shanghai also invested massively upgrading its infrastructure in anticipation to the event. Several new subway lines were built and street pavement retrofitted. On the top of this, few especially energy efficient pavilions (such as Shanghai's and Rhone-Alpes') will remain functional after the end of the exposition.

Figure 34 Artist view of the best urban practices area, Shanghai 2010

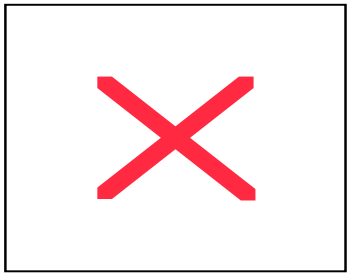

Figure 35 Artist view of Dongtan eco-city, ARUP

It is also worth noting that several initiatives were taken to develop large scale green areas and so-called "eco-cities" in Shanghai and around. Dongtan zero emission city project led to very promising designs, which even if they were not yet implemented doubtlessly inspired several other projects which are now in the pipe, either on exposition area after the end of the event or in peripheral cities such as Suzhou, Jiaxing or Hangzhou among others.

3.2. The academics and the development of roadmaps

We will extensively quote here after four suggestion of UNEP-Tongji study (Niu, Guo, Cao, Cao, Zhu, & Li, 2009), presenting the main suggestions of roadmap for the future of

Shanghai, and enrich this list mainly focused on energy efficiency of building with considerations on transport.

1 - Control of emission from the source

Accelerate the adjustment of industrial structure and energy consumption structure.

Efforts could be made to further optimize and adjust industrial structure, and vigorously develop modern service industry. Meanwhile, the objectives for the development and adjustment of the industrial structure in Shanghai should be identified, and specific measures for corresponding industry, system, and district or county could be established. The energy saving target could be specified and broke down. The accounting and evaluation work could be also enhanced. Industry guidance and industry policy could be established to accelerate circular economy, and continuously strengthen control, upgrading and elimination of high energy consumption industry, enterprises and products

Identify energy saving targets, and emphasize energy saving on supply side

Emphasis should be given to realize energy saving and emission reduction targets in key energy consuming industries, enterprises, equipment and products. Energy saving technology should be oriented towards the top 800 energy consuming enterprises with annual energy consumption exceeding 5000 tons of standard coal, including commercial, tourism, education and hospitals, which energy consumption made up 66% of Shanghai's total. The industrial association's function in coordination and supervision could be fully exerted, to carry out audit the energy saving and carbon emission status of the enterprises one by one. Product admission system could be established and enhanced to prohibit and control the manufacturing and consumption of high energy consuming products, and prevent industries and projects with high energy consumption but low output from being constructed in Shanghai.

Energy saving on the supply side includes energy saving from systems such as primary energy supply, power supply, heating system, etc. Energy saving on power supply side could be concluded by making establishing generation capacity plan for new and old generation sets, so as to reduce the coal consumption from comprehensive power generation. In order to achieve the above objective, efforts could be exerted to develop an operating mechanism which allows high efficiency generator sets to generate more electricity, and low efficiency generator sets to generate less electrify

Strengthen energy saving in building and transport sectors

Presently, energy consumption from building sector (including energy consumption by air conditioning system) is the bottle neck in the reduction of energy consumption due to its consistent increase over the years. Laws, regulations, standards and implementation rules with more stringent energy saving requirements could be issued. Corresponding planning and incentive mechanism could be established and implemented step by step. Energy efficiency in public buildings could be improved. The planning department could perform examination and approval of various buildings strictly in accordance with relevant laws and regulations, including the buildings designed with high energy consumption glass wall and oversized open space, especially the buildings for government sector and public buildings. Support could be given to enterprises in raising counterpart fund for project concerning energy efficiency renovation of existing residential buildings. For newly constructed buildings, the supervision and management over the overall processes including project application, design, construction, acceptance and use, etc. could be enhanced, so as to prevent incompliance with energy saving standards. Mature, high performance energy saving thermal isolation system could be promoted, new energy saving material and system could be developed, and outdoor testing base for energy saving system could be established. Qualification system for enterprises or organizations performing building design, material supply, construction, supervision, etc. could be strictly implemented, and practicable construction energy saving testing and evaluation system could be applied. Presently, 85% of gasoline

is consumed by motor vehicles, and the potential for energy saving from transport sector is at about 10%-30%. Policies focusing on public transport could be made, to actively promote intelligent transport control system, and reduce deadhead rate of public transport vehicles. Government public vehicle-using system could be reformed to save energy and use clean energies. Meanwhile, alternative energy sources such as dimethyl ether, hybrid power, hydrogen energy could be developed to as new approaches to save energy from transport sector

Accelerate the application of clean coal technology

The increasingly mature of clean coal technology makes it possible for Shanghai to use more coals. Shanghai will basically eliminate scattered coal use, and utilize coal in centralized power generation and chemical industry, so as to realize high efficiency and clean use of coal. Environmental policy maybe implemented in conjunction with price policy to maximize economic and social benefit. Strategies including centralized usage, centralized pollution control and high efficiency usage could be implemented to reduce pollutant emission while satisfying coal demand, and gradually mitigate the conflicts between coal consumption and environmental protection

Actively guarantee gas supply and effectively use gases

The use of natural gases could be under the centralized control in accordance with natural gases supply and intended purpose. The natural gas generator sets are not suitable for base load power generation, due to the insufficient supply and high price of natural gas. Based on the principle of economical and rational use of natural gas, it is not suitable for base load power generation in the future either, even though the natural gas supply may increase gradually. Therefore, natural gas is only suitable for use in high peak load power generation. Two pricing systems could be used for gas-fired power plant implementing peak load regulating operation and peak operation

Actively promote the development and utilization of renewable energy

The renewable energy in Shanghai is featured by limited supply and sustained high price, with the price for wind energy and solar energy respectively 2 times and 10 times the current on-grid power price. Therefore, policies could be established to accelerate renewable energy projects.

2-Strength process control, enhance energy saving and emission reduction as well as carbon source and carbon sink accounting

Process control and management must be strengthened and energy saving accounting system must be improved in order to proactively deal with climate challenge, and fulfill the energy saving and emission reduction targets of Shanghai by the end of the Eleventh Five Year Plan.

Establish and improve index system

Statistical Department at each levels could attach importance to energy saving and emission reduction as well as carbon source and carbon sink evaluation, by further establishing and improving energy saving and emission reduction as well as carbon source and carbon sink index system , monitoring system and evaluation system. In addition to incorporating the annual plan index system for energy saving and emission reduction and corresponding jobs of specific projects into the index system, evaluation on carbon source and carbon sink index could be gradually implemented to control total amount index and project task objective

Data standardization and normalization

Statistical Department could issue statistical standard and specification for carbon source and carbon sink, conduct accounting work of related data in accordance with the evaluation index of carbon source and carbon sink, and provide various statistics material and data required for phased summarization, analyses and evaluation.

Implement announcement system

Statistical Department could implement announcement system to publish carbon source and carbon sink index fulfillment status. Pollutant emission data online reporting system and emission reduction measure and allocation system could be established to realize online automatic monitoring and control over national major pollutant sources, construct pollutant emission three stage tridimensional monitoring system, and publish annual pollutant emission data of major enterprise monitored to the public.

3- Develop ecological carbon sink

Policy could be made to develop ecological carbon sink, both for wetlands and farmland protection

4- Promote public awareness

Featured by highly developed economy, high standards of living, and high energy consumption per capita, energy saving and emission reduction are not only the responsibilities of enterprises, but also closely correlated to living of people. Incentive mechanism with public and enterprises participation could be established to further the participation and supervision of public. Environmentally, it is to promote household and community activities and proactively advocate economic consumption pattern and living habits. Education could be carried out to raise the public's awareness of energy saving and emission reduction by encouraging people to take public transportation to work and travel, etc. In addition, relevant channel and system could be established for the announcement of climate change information so as to broaden public participation and supervision channel, and fully exert the supervision and opinion affluences function of news media. The transparency of decision-making process concerning climate change could be improved to realize scientific and democratic management of climate change.

On the top of UNEP-Tongji recommendations, an important axis to input in the roadmap is the improvement of transportation

Moving towards sustainable transportation

Finalizing key infrastructures

Shanghai has already developed a number of advanced transport infrastructures in its central areas. In particular, road density has certainly reached its critical size. From now on two main orientations could lead Shanghai action plans: connecting center to periphery and peripheral nods with each other and transform in parallel the car oriented city center to transit and soft oriented.

Key infrastructures to be built in priority are therefore suburban road networks that remain of a too low density and to complete it with still almost non-existing suburban rail connections. Until now rail has been mostly developed for long distance travels in China and there is much space left for the creation of dense intra-metropolitan rail network as in Tokyo area. This is absolutely necessary to absorb the intercity passenger which number will pass from 3.05 billion in 2010 to 5.5 billion in 2020.The framework for GYDR has already be planned and is centered on Shanghai with two wings: Shanghai-Nanjing and Shanghai-Hangzhou and then "within two hours" circular spaces around each of the three cities. In the end the total mileage could overcome 815km. The network could function like the intra-

city public transport system with high frequency and simple ticket fare structure. Ideally a uniformed ticketing system could progressively be instaured.

Freight could follow the same path with not only construction of highways but also intercity railways and further development along waterways, connecting industrial parks with city-center and main cargo areas such as Shanghai harbor, Pudong and Hongqiao international airports and all major docks along Yangtse River and key waterways.

Develop multimodal hubs and intelligible information systems

The keystone of such a network will obviously be well designed integrated transport hubs. One of the most important project: Hongqiao airport hub is currently under construction with a concentration of highways, airways and Railways, including highspeed within the same connection nod. Such experiences could be repeated in other strategic point of the city connecting rail and road and facilitating the passage from one system to the other.

Multimodal hubs shall not only be limited to huge strategic facilities. Smaller hubs shall be developed along with a hierarchy of transport systems adapted to different loads and types of travels, generating a smart grid of transport.

The metro lines are now developing along lines with an order of magnitude of peak loads of tens of thousands passengers per hours capable to cover long distances across the city in a small amount of time but in limited directions. Bus Rapid Transit (BRT) systems shall complement these lines were underground rail network are judged uneconomical. Such reserved lanes could be taken from existing road networks as it has been proven that such reduction of road areas for cars do not generate positive signals against congestion. Connection stations could then be developed all along metro spines with bus catchment areas draining passengers to them. Finally Shanghai still benefits from wide reserved paths for non motorized vehicles. This soft transport network could be greatly optimized if it could be connected to the mass transit system. The main barrier is certainly the lack of secured and accessible dedicated parking areas. This could be addressed in priority with massive construction close to every key station.

One of the main difficulties that travelers still face today in Shanghai is the lack of comprehensive public transport mapping and signalization. If it is now relatively easy to find one's way in Shanghai subway network, it is still much more difficult to pass from metro to bus and from bus to final destination by walk. Several key tools are missing yet such as trip calculators which easily allow passengers to prepare their trip including the most suitable mods and comprehensive mapping of bus lines, at least by areas.

Coordination between urban land use and transport

It is now well acknowledged that the success of a transport system not only resides in its own smart design. Apart from controlling the means, addressing the causes of travel could certainly the first stage of any transport policy.

There are several principal that Shanghai could apply in the year to come. First it could keep on controlling strictly floor area ratios in new urban development encouraging high density. The best way is probably to follow transport corridors with highest densities along axes of communication and concentration of major utilities.

Second, the land-use planning could optimize mix use with consistent ratios of services and public transport infrastructures not only for a given amount of population but also within a few minutes walking and/or a few minutes biking.

This second point supposes a work, not only on planning but also on design of the urban forms. It is easily understandable that certain configurations disqualify soft travelling like large four and above

lanes highways even with subterranean or elevated crossing ways. Thus, guidelines and even prescriptions could be progressively tested and instituted at neighborhood scale ensuring true walkability with the highest level of comfort and security.

There is a vicious circle in urban development that has to be integrated by planning authorities which is that increasing road ratios and parking lots to fight congestion is space consuming and generates an environment unfriendly to non motorized travelers which in the end encourage the use of individual cars which increase congestion…

Consolidating regulatory and financial framework

Limiting car use within central area is crucial for a megacity concerned by its environmental quality and by its carbon footprint. In Shanghai all areas surrounding large roads are heavily contaminated by particulates, exhaust gases and last but not least noise. Apart from the natural dissuasion generated by the constitution of an efficient and comfortable public transport system, rules are a necessary tool to further reduce car use. Shanghai made few experiences such as auctioning of vehicle plates but each time with unavoidable drawbacks. Auction quotas were for instance quickly answered by the purchase of suburban licensed vehicles. Also as licenses are long lasting, such rules can nothing but delay increasing motorization. Other measures such as road congestion charging, fuek tax, eventually linked with the category of the car and above all parking limits could become the main instruments in the future.

Along with regulations, the question of transport systems finances still lack a sound answer. The input of urban transport is large and its payback takes a long time. Therefore the design of investment and financing tool is a key question. The main tools that should be further developed are: developmental financing (by agencies usually sustained by government) is very much adapted to the transport sector where it can correct market failures and help funding strategic projects; BDOT (Build Develop Operate Transfer); PPP (Public-Private-Partnerships) as it was done for Beijing Line 4. Stock finance also already exist in Shanghai with the issuance in 2003 by Shanghai Jiushi Company of Shanghai rail transport construction bonds in the amount of 4 billion RMB with a 15 years term and a coupon rate of 4.5%.

Reforming administrative organization: towards "one region – one transport administration"

Among the different challenges involved, the coordination among different territories is a difficult issue, which combined with sector organizations lead to a very complex administrative system that can prevent many project from ever happening. Sector separation mainly comes from the local transcription of the State level structure. This can be overcome by express demands from local authorities motivated by a specific case to develop their own administrative structure. In the case of Shanghai the establishment of a cross-sector and cross-territory institution at the scale of the Yangtse River Delta would be a great progress.

3.3 On current debates

At the national level it is increasingly sure that a carbon tax will see light in China during the 12th 5-Year Plan (see from the influent Jiang Kejun (ERI) http://www.chinadaily.com.cn/china/2010-05/10/content_9826546.htm). However the details on what could be the measures for carbon cap-and-trade and/or tax in China are still debated at the time of writing. What seems clear is that a large set of measures will likely be deployed over the coming 5 years, which might be different in various sectors. A carbon tax for Building is likely but also pilots of cap-and-trade (Tianjin, Shanghai, Xiamen...). Deployment of national cap-and-trade in various sectors will most likely take place -in particular Steel and Cement- while trying to keep CDM cash influx in sectors already covered (wind, solar, hydro). The power sector is still facing a huge debate for Power, with the fear that cap-and-trade

might lead to a rise in price index. Various decision makers have not clinched the debate; however it is clear that Shanghai will be best placed to benefit form these measures in taking a lead towards a modernized urban (and industrial) economy, and that several lobbies are pushing for this.

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