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Urban energy and environmental policy: the case of Shanghai since the 2000's.

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Abstract: Shanghai has observed a fast economic growth since the market-oriented and Open-door reforms, which brought stress to the local and global environment. Economic growth is often coupled with environmental degradation. This thesis aims to illustrate how Shanghai is incorporating the concept of sustainable development to maintain its economic development. Following National goals of development, Shanghai developed its own environmental governance with specific objectives. The city has processed a similar approach of National governance but has attained different results. The city has adapted efficaciously its own policy by changing the structure of its economy, modifying the energy structure and increasing the share of renewable energies by allocating significant budget to meet the objectives. The governance can be defined as successful according to substantial results such as different techniques of mitigation, the decrease of energy consumption after 2013 and a better air quality. Shanghai has acted in local level of actions to implement efficacious environmental governance.

Key words: Shanghai, sustainable development, environmental governance, pollution, EKC, energy efficiency

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1. Introduction

China has experienced rapid economic growth since 1978 when the whole process of substantial economic market-oriented and Open-door reforms was initiated (Chen & Feng, 2000). Environmental pollution is an unavoidable consequence of structural changes that have occurred throughout Chinese transition to the market economy. This fast national industrialization, urbanization in this emergent economy created heavy demands on energy consumption. The worldwide impact of China is unique. Chinese economy is not only large but also particularly resource-hungry (The Economist, 2015). It accounts for roughly 16% of world output but consumes between 40% and 50% of the world's main natural resources such as coal, copper, steel, nickel, aluminum and zinc. Energy production in China rises by 38% while consumption grows by 47% in 2015 (BP Outlook, 2017). Without any doubt, China will deal with major complications meeting the demand in energy at this current rate.

This situation confronts with the notion of 'Sustainable Development'. This could be defined as economic development that is conducted without depletion of natural resources (Mensah & Castro, 2004). Industrialization and environmental quality often targets oppositional goals; however both are heavily linked as it is explained in the Environmental Kuznets Curve. According to the theory, in the first stages of development, more weight is given to industrialization objectives. However, as income per capita grows, environmental awareness increases and there is a shift in national policies due to the ecological consequences of growth. China persists now at this turning point with the signature of Paris Agreements in October 2016 and the forthcoming 13th Five-Year Plan. As reported by the European Commission in 2015, China is since 2006 the largest emitter of Greenhouse Gases, reaching 29% of global emissions in 2015. It is impossible to deny the fact that China is one key leader in international economy (Vidal & Adam, 2007).

Shanghai can be considered as an illustration of a successful economic development by showing the path to other eager Chinese areas (Zhang, 2003). According to the last UN report[1], cities can be held responsible for 70% of global emissions. Therefore, Shanghai will be a vital actor in the sustainable transition China is focused on. Shanghai is now in 74th position in *Arcadis* ranking of Sustainable cities index of 2016[2]. This ranking establishes a classification of 100 global cities on three dimensions of sustainability: people, planet and profit. These symbolize social, environmental and economic sustainability and offer an indicative picture of the health and wealth of cities for the future.

1.1 Aim

This paper investigates how Shanghai aims to conciliate the objectives of economic growth and environmental quality. How Shanghai officials will adapt their environmental policy to meet sustainable development with the national goals of environment (increasing of energy efficiency, diversification of energy structure or increasing renewable energy) and respect international agreements? Shanghai has had to cope with several challenges since the beginning of its development: air quality, adaptation or mitigation to climate change, urbanization, pollution, health issues, and environmental degradation. Explaining how concretely Shanghai has moved toward cleaner transition can be highly beneficial in order to transpose this framework to other emerging cities in the world. Shanghai is perceived as the largest emerging city in the world. If the transition appears successful with a population of 24 million citizens, the framework can be suitable for smaller emerging cities all over the world. Those cities may confront similar circumstances in the future. Up to now, several articles have covered this domain but focusing on energy, policy governance, or environmental aspect. There is no clear and specific framework for sustainable development in Shanghai as a whole. This thesis will conduct a literature review on the energy and environmental policies of Shanghai and understand how the concept of sustainable development is incorporated in those policies.

[1] "*Sustainable Development Goals Report 2016"*. The world officially began implementation of the 2030 Agenda for Sustainable Development—the transformative plan of action based on 17 Sustainable Development Goals—to address urgent global challenges over the next 15 years.
[2] *Arcadis* is the leading global natural and built asset design and consultancy firm.
[3] World Urbanization Prospects, 2014
[4] BRICS is the acronym for five major emerging national economies: Brazil, Russia, India, China and South
[2] *Arcadis* is the leading global natural and built asset design and consultancy firm.

China has frequently retained attention in the world by its speedy economic expansion in such brief period of time. Meanwhile, pollution and environmental concerns have been in the points of interests of numerous observers. Trying to comprehend how the biggest city of China will adapt toward sustainability could be highly constructive to extend these policies all over the country to respect global agreements.

1.2 Structure

The first section provides an overview of the historical and current development of Shanghai's economy. It draws, among other sources, on the statistical information from Chinese Statistical Yearbook of available years.

The second section provides the theoretical background of this thesis. Here, some concepts of Sustainable Development and the Environmental Kuznets Curve (EKC) will be covered, both in a generic and specifically in an urban context.

Following to the urban framework, the emphasis will be specified on three main aspects of environmental management. Shanghai is actually facing three challenges: energy problematic, air quality and adaptation to climate change. Actually, energy is one crucial aspect for sustainable development; Shanghai and China have emphasized it in the objectives to achieve for the future.

Lastly, environmental policy and governance of the municipality in different levels of power of Shanghai will be described. Some concrete measures will be explained. National goals and Shanghai goals will be compared.

2. Methods

This literature review was conducted between January and May 2017 and surveyed the literature in English in various databases. The papers relevant for this review were identified by a computer-based search done in the Web, advice from professors and Lund Library database.

Table 1: List of relevant literature

N°	References	Origin	Conception	Type
1	Statistical Yearbook Data (from 1978 to 2015)	China	Official	Quantitative
2	Shanghai Environment Protection Bureau (from 2009 to 2015)	China	Official	Mixed
3	Shanghai International Urban Environment and Sustainable Development Conference (2002)	China	Independent	Mixed
4	Low Carbon Shanghai ENRP, Harvard Business School, Cheng & al (2014)	USA	Academic	Mixed
5	Shanghai Manual: A Guide for sustainable Development of the 21st Century, United Nations (2010)	International	Independent	Mixed
6	Sustainable Low-Carbon City: Development in China, World Bank (2012)	International	Independent	Mixed
7	World Economic Situation and Prospects, United Nations (2013)	International	Independent	Mixed
8	Cities, Climate Change and Multilevel Governance, OECD (2009).	International	Independent	Mixed
9	World Energy Outlook, IEA (2016)	International	Independent	Mixed
10	BP Statistical Review of World Energy – 65th edition, BP company (2016)	UK	Company	Mixed
11	Evaluation of sustainable land management in urban area : case study of Shanghai, Hé & al, 2016	China/ Netherlands	Academic	Mixed

12	A low Carbon sustainable strategy using cdm methodological approach to large commercial building in Beijing and Shanghai, Jiang P., 2009	UK	Academic	Mixed
13	Climate Change and energy policies in Shanghai: a multilevel governance perspective, Francesch-Huidobro M., 2016	Hong-Kong	Academic	Mixed
14	Towards low carbon based economic development: Shanghai as a C40 city, Li & al, 2017	China/ Netherlands	Academic	Mixed
15	Consumer attitudes towards renewable energy in China – Shanghai, Hast & al, 2015	Finland	Academic	Mixed
16	Economic development, urban expansion and sustainable development in Shanghai, Yue & al, 2014	China USA	Academic	Mixed

Source: own construction

Results have indicated that 16 specific items were identified as relevant in the different databases (cfr Table 1). Those pieces of literature come from several Chinese Statistical Yearbooks, reports from several independent international organisations (UE, UN, OECD, IEA) and Shanghai Environment Protection Bureau. Some reports are from international companies such as BP. It exists also different academic articles, thesis and book chapters in the areas of sustainable development, environmental sciences, economics, humanities and development.

3. Shanghai economic overview

Located in the Yangtze River Delta in Eastern China, Shanghai sits at the mouth of the Yangtze River in the middle portion of the Chinese coast. The province municipality borders the Jiangsu and Zhejiang Provinces to the west; Anhui is regularly considered as a neighboring province. Shanghai shares the coast at the east by the East China Sea. The municipality has frequently benefited from a convenient location in reference to harbor or seaport. The area of Shanghai consists of 6340.5 mostly flat km^2. There are 19 administrative areas in Shanghai.

In terms of population, Shanghai is facing important demographic defies: growing migrants workers, thrilling population distribution and an ageing population. The whole population in 2016 is estimated to be over 24 millions; which means it has surpassed the entire population of Taiwan. It is still hard to calculate exactly the number of inhabitants of this 'Megapolis' due to the complicated census and the absence of massive amounts of unregistered citizens. According to Shanghai Municipal Government in 2015, the latest official data reveal that the estimated population of Shanghai is 24,152,700 people; this represents a slight decrease of population around 0.4% from 2014. The population represents around 1.7% of overall China and has been stable since 2003. The population density is therefore around 3,760 per km^2; meanwhile the national density is 146 habitants per km^2. Consequently, the city is the most crowded city in China. Shanghai is seen as an example for other Chinese municipalities but also for officials of other enormous emerging cities. All the measures carried out by the city are under scrutiny by myriad observers. Shanghai is contemplated as a large-scale laboratory (Früh & Zakhor, 2004). Figures 1 and 2 reveal drastic increases in both density and population from 1998 to 2010; and recently a slow down. UN projections of Shanghai's population[3] are around 30.75 million in 2030; when Chinese officials are more optimistic following the abandon of 'One child policy' around 55 million in 2050 because of the fast-paced urbanization coupled to sustained economic growth (Shenshen, 2010). For bureaucrats, it is crucial to keep control of this tremendous community alongside urbanization, growth of population and diversification of density.

[3] World Urbanization Prospects, 2014

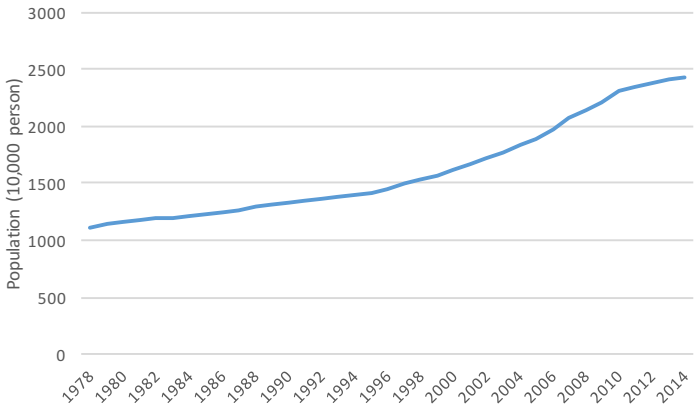


Figure 1: Population of Shanghai (1978-2014). Source: Chinese Statistical Yearbook (2015)

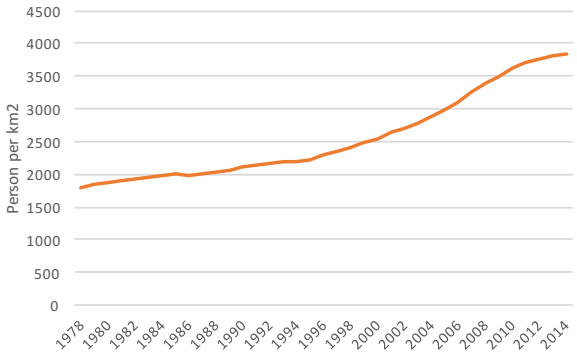


Figure 2: Density of Population (person per km2). Source: Chinese Statistical Yearbook (2015)

Shanghai has become the symbol of Chinese modernization and the increase of power for China after the economic reforms launched in 1978. Shanghai has been one of the fastest developing cities in the world for the last twenty years, with double-digit growth nearly every year since 1992, with the exception of the global recession of 2008-2009 and recently in 2012 (Drobescu & Dobre, 2015). The average variation is around 12% a year from 1978 to 2014 (cfr Figure 3).

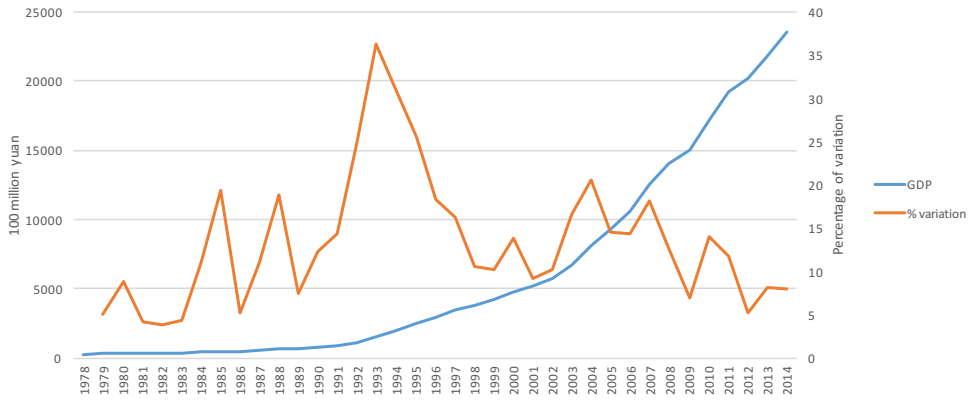


Figure 3: GDP of Shanghai 1978-2014 (current prices). Source: Chinese Statistical Yearbook (2015)

On Figure 4, the structure of Shanghai GDP within China is examined. Surprisingly, Shanghai being one of the major financial hub in the world and the most crowded city in China, only represents 3.70% of the Chinese GDP in 2014. Moreover, the trend is somehow in decline, policy makers expect this value to decrease in a near future.

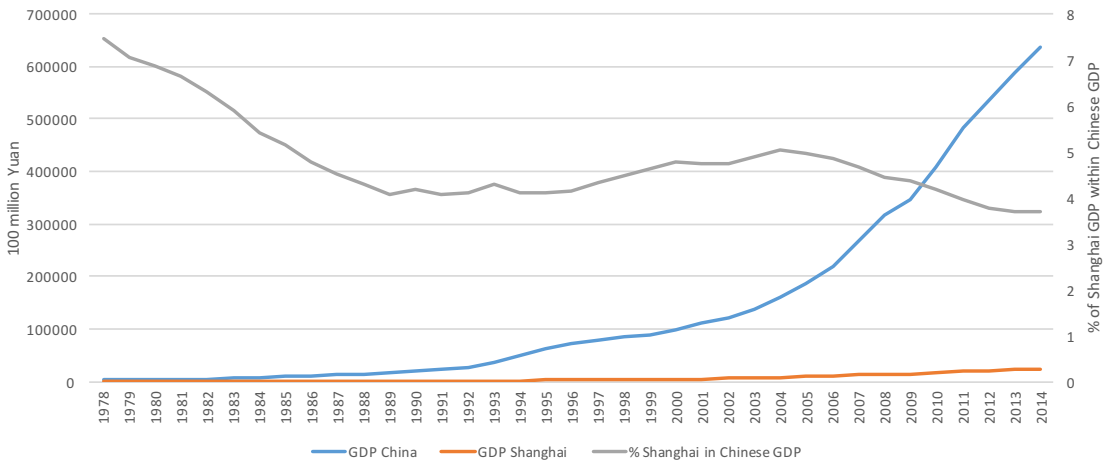


Figure 4: GDP of Shanghai and China. Source: Chinese Statistical Yearbook (2015)

Both China and Shanghai municipalities hold similar exponential evolution. As an example, Tokyo, which can be perceived as similar in terms of population and economy, represents 39.19% of Japanese GDP (Data World Bank, 2016). However, a comparison between cities of BRICS[4] countries should be more appropriated.

Table 2: Comparison GDP of BRICS 2014

	Sao Paulo	Delhi	Moscow	Shanghai
Population	12,038,175	23,036,600	12,197,596	24,683,400
GDP (PPP in millions US$ of 2014)	430,510	283,637	553,318	594,005
GDP per capita (PPP US$ of 2014)	20,650	12,747	45,803	24,065
% of national GDP	4.49%	3.73%	14.31%	3.70%

Source: World Bank & Brooking University (2015)

[4] BRICS is the acronym for five major emerging national economies: Brazil, Russia, India, China and South Africa.

On Table 2, Shanghai is compared with other similar metropolises of other emerging countries. Moscow could be an exception as being the major driver of the domestic economy; all other examples (Beijing or Mumbai) confirm that large cities in BRICS contribute usually less than 5% of the overall national GDP.

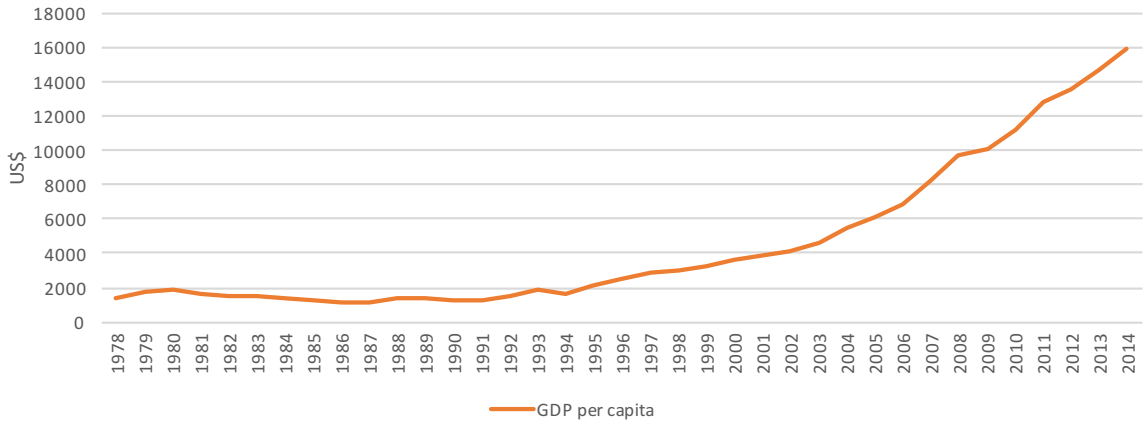


Figure 5: GDP per capita Shanghai (1978-2014) (current price US$). Source: Chinese Statistical Yearbook (2015)

According to the GDP per capita on Figure 5 (15,800$ in 2014), Shanghai remains at the level of Thailand or Brazil (78th in the ranking of World Bank). If the trend were confirmed (increase of 7.8% per year), the GDP per capita would be in 2016 around 18,488$ (close to Bulgaria, Lebanon or 64th in the ranking). At the same rate, the forecast will reach around 25,150$ in 2020, same amount for Russia or Hungary (50th in the ranking). Those statistics in relative terms stand rather impressive for the size of a city. As a contrast, Zurich, Oslo, Macau and Hartford stay the first cities with around 89,000$ GDP per capita. However, those cities have major dissimilarity with Shanghai in number of population. Shanghai gathers high values for GDP per capita in case of comparison with BRICS cities in Table 2. As already enlightened, Tokyo may represent the only similar example of an opulent city, with a population of 37 million inhabitants and almost the double in GDP per capita around 43,600$.

Table 3: GDP per capita in Chinese Provinces in 2015 (current US$)

Province	PPP (US$)	GDP	Population (million)	% of Chinese GDP
Tianjin	30,611	1,653,819	15.31	2.40
Beijing	30,196	2,296,859	21.61	3.33
Shanghai	**29,431**	**2,496,499**	**24.20**	**3.62**
Jiangsu	24,950	7,011,638	79.68	10.18
Zhejiang	22,015	4,288,649	55.23	6.22
Inner Mongolia	20,160	1,803,279	25.07	2.62
Fuijan	19,271	2,597,982	38.22	3.77
Guangdong	19,140	7,281,255	107.86	10.57
Liaoning	18,531	2,874,339	43.86	4.17
Shandong	18,194	6,300,233	98.18	9.14
China	**14,248**	**68,905,100**	**1,371.22**	**100**
Anhui	10,207	2,200,560	61.13	3.19

Source: IMF WEO (2016)

Table 3 approves the previous findings. Firstly, Shanghai is not the chief contributor of national GDP as a province. Whereas Shanghai has the third highest GDP per capita among all Chinese provinces; Shanghai province doubled the national GDP per capita. According to Figure 6, 48 Chinese cities are in the top 300 largest metropolis in the world (ranked by GDP), Shanghai remains in the 16th position. Shanghai rests first as major city, just in front of Beijing. Represented in green, Nianjing, the capital of Jiangsu province and Hangzhou of the province Zheinjang are close by and obtain better results for neighboring cities. All other cities are actually benefiting from a great economic activity and relatively low population.

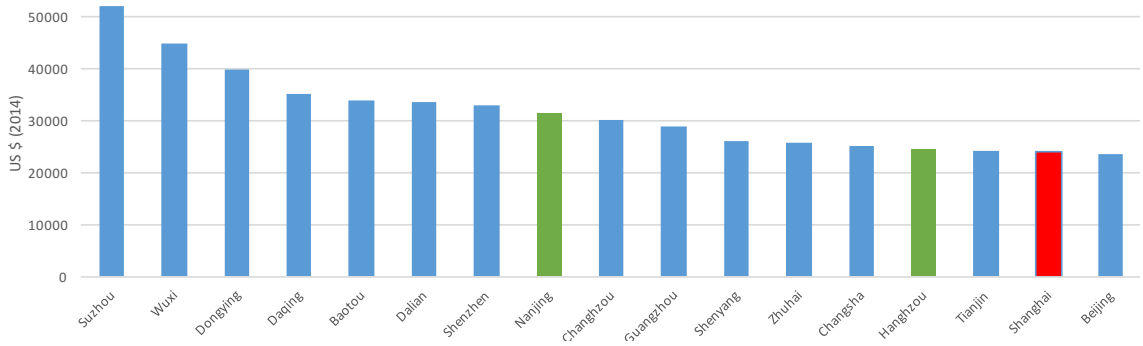


Figure 6: GDP per capita in Chinese cities in 2014. Source: Brooking University Monitor Ranking (2015)

With the Open-door policy for abroad trade liberalization, China is often considered as the 'workshop of the world'. Shanghai represents the main gate of this factory and the first terminal of the port-containers in the world, as volume of exports of goods[5]. Its economic growth has typically been about the degree of openness and its international role. In 1978, Chinese Government put in place a series of economic reforms to open Shanghai to the outside world by creating Special Economic Zone (SEZ) in order to attract foreign capital and multinational companies (Jarreau & Poncet, 2012). After 1990, the Chinese state has promoted further development of the metropolis to enable the deployment of new areas of specialized activities in the production of goods for consumption and foreign trade: one of the strengths of Chinese economic policy of the last 30 years (Yang, 2002).

The city has evolved from an industrial and commercial city into a national economic center. The rapid development of finance, insurance, trade, transportation, communications, real estate and other types of the tertiary industries have raised the proportion of services in Shanghai's GDP from 19% to 64% within 25 years.

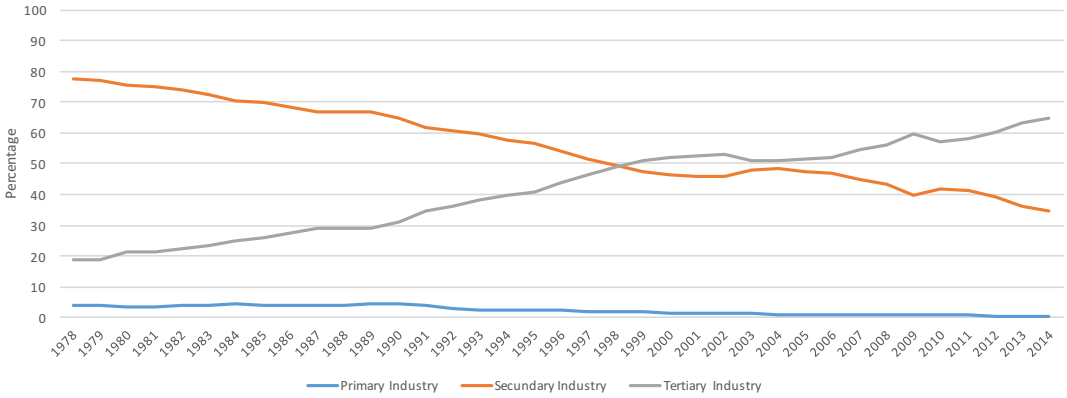


Figure 7: Structure of Shanghai GDP (1978-2014)(current price). Source: Chinese Statistical Yearbook (2015)

In the structure of Shanghai's GDP (cfr Figure 7), the total amount of primary industry has remained low from 4% in 1978 to less than 1% nowadays. The replacement of importance between Secondary and Tertiary is even more interesting. The Tertiary symbolizes 64% of the total GDP structure. Secondary industry came from 77% to 34% and it is still decreasing. Figure 7 demonstrates clearly how Tertiary industry becomes the main backer of the GDP. The 3 largest industries in the services were finance, retail & wholesale, and real estate.

[5] World Shipping Council

Referring to Table 4, Shanghai's six focal industries are: electronic information products, cars, petroleum chemicals and fine chemicals, fine steel, complete sets of equipment and biological medicine. Shanghai has been undergoing major industrial restructuring. Shanghai is perceived as the first Chinese city that has entered the post-industrialization phase. The share of low value-added manufacturing has decreased significantly, particularly the textile and heavy-equipment manufacturing industries as several of them have relocated outside Shanghai, mainly in neighboring provinces (HKTDC, 2016).

Table 4: Output share of Key industries in industrial sector in 2015.

Output Share of Key Industries (2015)	**% share of total industrial value-added**
Computer, communications and other electronic equipment	17
Automotive manufacturing	16.7
General equipment	8
Raw chemical materials and chemical products	7.9
Electrical machinery equipment	6.9
Smelting and pressing of ferrous metal	3.8

Source: HKTDC (2015)

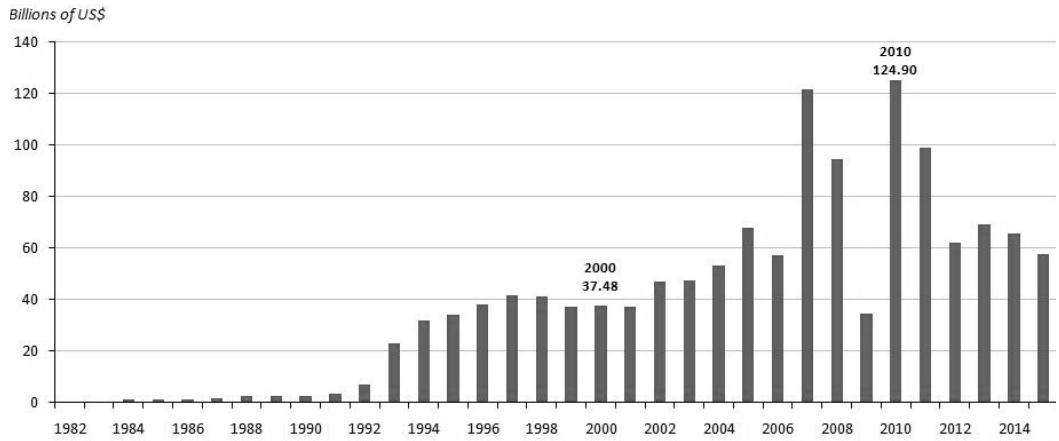


Figure 8: China's Net FDI (1982-2015). Source: Davies (2014)

In international activities, FDI became crucial for the economic expansion of China. According to IMF, the trend is not crystal-clear but FDI quantities have been fluctuating since the sizeable reforms of 1978, and impacted by the global crisis of 2008-2009. Shanghai's share of the sum of FDI in China has not stopped increasing (cfr Figure 8). That proportion reaches the amount of 14.6% in 2016 according to Shanghai Municipal Government (Davies, 2014). This percentage confirms how significant SEZ behave to attract foreign capital. Shanghai has commonly been a major attractive destination for FDI. Several multinational companies and external R&D centers established in Shanghai for various reasons: cosmopolitan and modern city, sophisticated and affluent customers or highly educated and skilled labor force. All those pieces of evidence create the ideal receipt for establishing a new subsidiary in Shanghai and therefore granting access to the tremendous Chinese market. Over the last decade, the shift in the pattern of FDI towards services has been particularly vital. Provided its prominence, Shanghai municipal government may continue to devote efforts to attract FDI and appealing foreign funded enterprises helps to reshape Shanghai's economic landscape (World Bank, 2011).

The next section will cover the theoretical concepts of this thesis.

4. Sustainable Development

4.1 Theoretical background

Sustainable development remains a modern concept. Our world is currently facing numerous of environmental challenges such as pollution, air quality, global warming, waste disposal, ozone layer depletion and several more. Every year, scientists discover new visible consequences on earth, human or animal due to climate change (Intergovernmental Panel on Climate Change). Societies gradually comprehended this global concern: first some authors, then some ecological associations, some political wings and finally entire governmental directions (Bâc Dorin, 2008). Simultaneously, economic development and advancement are observed in nearly every country in the world. Is there a relationship between environmental destruction and economic growth (Lamia & Derbali, 2016)?

In the beginning, Sustainable Development was briefly described in articles and books around the 60's (Tragedy of the Commons (Hardin, 1968), Blueprint for Survival by the Ecologist magazine (1972)). Rachel Carson mentioned a similar concept following the large ecological disaster of Santa Barbara (oil spill in 1962) in her book *Silent Spring*. The volume brought together researches on toxicology, ecology and epidemiology to suggest that agricultural pesticides are building to catastrophic levels, linked to hurt animal species or human health (IISD, 2012). In 1969, the National Environmental Policy act is signed in the US, one of the first countries to establish national legislative framework to protect environment (IISD, 2012). Few years later, Environmental Protection Agency was created in the US, sustainability's idea was spread. In 1972, the first international official meeting about this topic was in Stockholm, administrators focused on human interactions with the environment (acid rains in northern Europe). A declaration of United Nations was agreed containing 26 principles[6]. Since then, several authors used sustainability as the core structure for books and articles. Various events occurred trough History brought up some food for thought: following nuclear accident in USA and unavoidable consequence on environment, oil crisis and its limit to growth and various more.

In 1983, *Bruntland Commission* was settled by United Nations to pursue Sustainable Development together. After dissolving, the Commission released *Our Common Future*,

[6] Declaration of Stockholm in 1972

also known as "*Brundtland Report*". For the first time, Sustainable Development concept was clearly and officially explained in a pure definition.

"Sustainable development is development that meets the need of the present without compromising the ability of future generation to meet their own needs. It contains within it two key concepts:

- *The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given*
- *The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs".*

Bruntland Report

Bruntland's definition is still considered as a reference when it comes with Sustainable Development. But the term has since become like a rubber band that can be stretched in all directions. The report expanded the concept to not only includes environmental concerns, but also social and economic dimensions. It has also contained some new specifications and modernizations due to recent technological progress. All nations have different opinions or interpretations of this noble cause. Following *Bruntland report*, the United Nations developed several frameworks about sustainable development. Some specific goals were generated. This will be covered later on.

4.2 Sustainable Development and the Kuznets Curve

In 1972, the report of the Club of Rome also called "The Limits to Growth" concluded that economic development has important environmental impacts and the future world may collapse because world economy will reach its physical limits in terms of non-renewable resources, agricultural production and excessive pollution (Tahvonen, 2000). Economic growth has frequently been coupled with environmental damage in Human History with the Industrial Revolution representing a notable illustration (Deudney, 1990). Environmental degradation cannot be avoided in the first stages of development. The relationship between economic growth and environmental concerns brought about an extensive debate that could be best illustrated explained by the Environmental Kuznets Curve (EKC) concept as shown in Figure 9 (Panayotou, 1993).

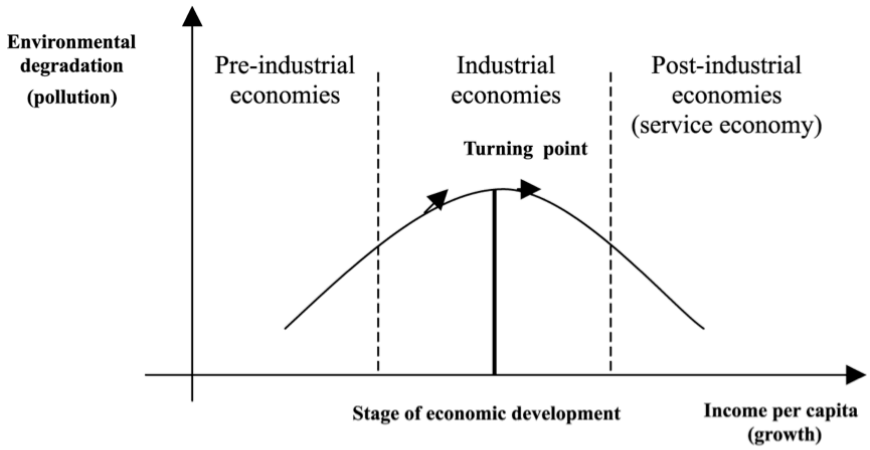


Figure 9: EKC concept. Sources: Panayotou (1993)

The EKC concept could be defined as follows. In early stages of economic growth, the environmental quality deteriorates and improves in later stages as an economy develops (Stern, 2004). Environmental pressure rises faster than income in the early stage of development and slows down relative to GDP growth at higher income levels. Figure 9 confirms that the nature of the economy will impact differently the degradation (from pre-industrial, industrial to services economy). This relation forms an inverted U-shaped curve and is similar to the original curve proposed by Simon Kuznets (Kuznets, 1955) concerning the relationship between income inequality and economic growth.

Following the EKC concept, further economic growth can improve environmental degradation after an economy has reached a turning point or adequate level of economic growth (Kaika & Zervas, 2013). This turning point represents the level of income (per

capita) beyond which environmental degradation can be de-linked from the process of economic growth. For nations with higher income levels, economic growth improves the quality of environment.

The EKC concept may likewise extent to other theoretical explanations. A significant structural change can modify greatly the energy consumption, as demonstrated in Figure 9. Moving from agriculture to industry and services may cause major shifts in final energy use (Schäfer, 2005). It is clear that structural change and technological progress are of extreme importance (Stern, 1996). This may elucidate certainly the shift downwards after the peak of environmental degradation in some cases. Additional factors may influence the environmental degradation; stronger policies and regulations can prevent emissions and pushing greater efficiency. It is understandable that the EKC cannot apply to every situation or every country in the world. It stays context specific due to the complexity. As income increases, preferences of buying of people may vary, societies prefer different products (local economy), environmentally friendly products or items not produced in the same country (Munasinghe, 1999).

It exists two formulations for the EKC: the strong and the weak hypothesis (Kander, 2002). The strong variant implies absolute improvements in environmental quality, while the weak only suggest relative improvements. The weak hypothesis implies that initially an economic growth process will cause a relatively increased stress on the environment, but after a peak the reverse situation will appear: continuous economic growth leads to relatively decreased stress on the environment. EKC doesn't eternally differentiate between a relative and an absolute environmental improvement. Some indicators will confirm steady deterioration and some environmental problems will be worse in case of stocks than increasing flows. It has been proven with some kinds of pollutants within GHG (Falk & Mendelsohn, 1993).

In case of urban context, such as Shanghai, the EKC may reflect differently than in national context with absolute improvements being more frequent (Li & Ma, 2014). Improvements can be found in emissions (calculated as an environment degradation) efficiently diffused, that has been observed in China. Variation in energy intensities may have a deep impact on the EKC curve; China has tried to significantly decrease its energy intensity. As highlighted before, China being considered the workshop of the world, parts of its emissions and energy consumption occur to satisfy needs abroad. Therefore, the energy consumption and the pollution of the country may look entirely different

when the international trade is also measured. It appears when energy use is not attributed to the producer but to the final consumer. The situation is especially true for China that is predominantly based on a coal-fuel industry (large emitter of emissions) (Kander et al, 2017). To measure environmental degradation, a consumption-based analysis should be applied; it should alter expressively the EKC.
Some questions remain without responses about Shanghai. Has Shanghai reached the turning point? Does Shanghai want to avoid the environmental degradation? Does Shanghai only focus on economic growth? Which path will Shanghai use in the EKC? All those questions will be answered in the coming sections.

As previously described, critics for the EKC appeared in several articles (Cole (2003), Kaika & Zervas (2013), Perman & Stern (2003) and various others). Here comes one of major distinction between developed country and an emerging nation such as China. Environmental scenarios are dynamic and subject to varying conditions resulted from pollution impacts. Environmental policy can seriously impact the energy consumption with regulations or subsides, e.g. pushing inhabitants to use gas or electricity instead of coal or replacing fuel-based boilers (Grubler & al, 2012). Final environmental degradation depends on the timeframe, the measured particles and myriad other factors. Income-pollution variable can be modified according to democracy, literacy, income inequality, price shocks, structural changes and national policies (Van Alstine & Neumayer, 2010). The size of the country, the energy structure and the demand of environment protection are other factors that may affect the EKC concept of the country.

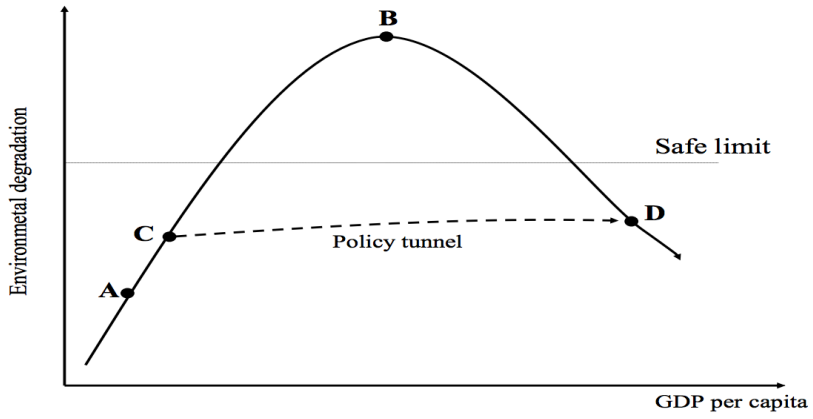


Figure 10: Policy tunnel in EKC. Source: Munasinghe (1999)

Not all countries need to face an U-shaped curve; especially in the hypothesis of leapfrogging or tunnel the EKC. Leapfrogging is a notion similar to the catch-up hypothesis (Abramovitz, 1986): being backward carries a persistent potential for rapid advance. The notion of leapfrogging in the process of industrialisation, where a country moves straight to the use of more advanced technologies without needing to follow the same technological trajectory as its more industrialised predecessors, is unquestionably an attractive technique (Van Benthem, 2015). It provides a certain resonance in the field of Sustainable Development, where the necessity to use cleaner, more energy efficient and less environmentally damaging technologies has been more urgent (Goldemberg, 1998). Emerging or developing countries have a strong opportunity to acquire from previous development strategies of industrialized countries by skipping less efficient, old-fashioned, more expensive and polluting technologies. The EKC could be updated for some emerging states: tunnelling policy trough the EKC. On the Figure 10, and according to EKC theory, the country is supposed to reach the turning point in B. However, the country can immediately adopt measures or strategies in its development (optimal paths) or energy sector to go from C to D point by avoiding high degradation periods and being below safe limit (Munasinghe, 1999). The greatest illustration of leapfrogging measure is the telecom sector for diverse African countries. The countries directly developed mobile networks instead of lines of cables buried in the ground (James, 2009). Measures in energy policy can be discouraging enterprises using of coal-fired energy production by taxes and subsidizing purchase of renewable or clean energy boiler. For instance, Shanghai municipality implemented a novel energy mix via a strict policy and subsides system (SEPB, 2014).

4.3 Sustainable Development Framework

Nowadays, the concept of Sustainable Development became more common. Public opinion turns out to be aware of this problem due to visible consequences of climate change. Several countries took the led to perform concrete actions.

However, concept of Sustainable Development is still uncertain. This concept has evolved and remains still under evolution. Several authors and scientists have been trying to set this framework without any real success; it is often vague or meaningless. A global framework is problematic to generate due to the range of disparities. A framework for opulent European cities is dissimilar than the one for poor African megapolises; a framework for European cities less than 5 million inhabitants is different than the framework for megapolis fulfilled by more than 10 million people in Asia (EU Framework for sustainable cities for global city, 2005 [7]). A viable Sustainable Development framework is an important requisite to completely comprehend this challenge.

Originally, United Nations offered a serious framework based on the same 3 main pillars of *Bruntland report*. As the Figure 11 displays, it remains clear that Sustainable Development is an addition of several factors: environment, social and economic.

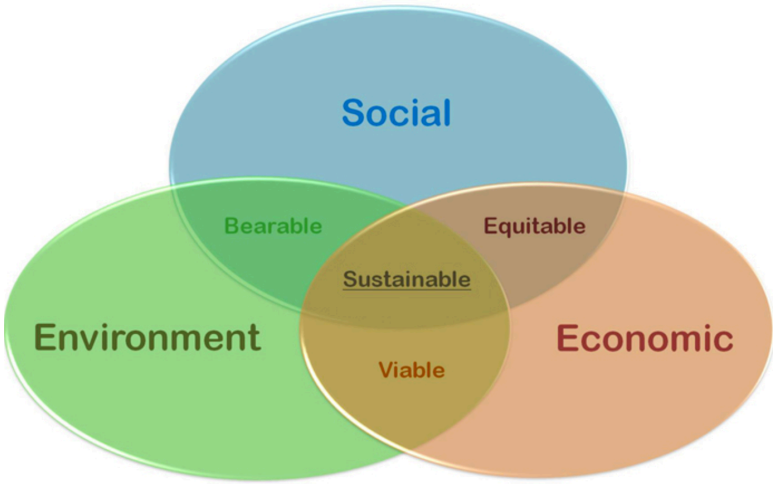


Figure 11: Sustainable development framework. Source: UN 1992 – Rio Conference (1992)

[7] Accessible online at http://ec.europa.eu/health//sites/health/files/nutrition_physical_activity/docs/ev_20151216_co07_en.pdf Framework of the UE is only valid for cities under 5 million inhabitants

Maintaining economic advancement and progress while protecting the long-term value of environment could convert to a simplified definition of Sustainable Development. That is the reason why a majority of people tends to believe that it only focuses on ecology or environment but it is more complex. Several companies manipulate this customized framework to explain their ecological values to their customers on their websites. This framework represents the base of all more advanced frameworks in the future.

Then, the United Nations adapted the previous framework by giving concrete goals to achieve. The UN updated this framework by subdividing the former framework in a clear chain of dissimilar goals. As the figure 12 displays, the 8 Millennium Development Goals[8] (MDGs) were settled in 2000.

Figure 12: 8 Millennium Development Goals. Source: UN (2000)

At that point, the United Nations confirm that all goals are interconnected; the key to success is to tackle commonly different goals. Those goals were concentrated on poverty, health issue, gender equality, economic development and environmental sustainability. Since then, remarkable progress has been made in achieving these goals, but uneven across countries (Fehling & al, 2013). Implementation problems occurred during the global recession. Beside that, the UN Secretary-General deplored a lack of accountability to gauge the success and an insufficient interest in Sustainable Development (report of

[8] Accessible online at: http://www.un.org/millenniumgoals/environ.shtml

General Assembly, 64th Session in 2010). The 8th goal 'Global Partnership for development' was heavily criticized because of its inefficiency toward high-income countries. Once again, crisis of 2008 represents the principal cause of decreasing in international development aid.

The 7th goal 'ensure environmental sustainability' symbolizes the most interesting one considering the topic of this thesis. It contains 4 different targets. Firstly, integrating sustainable development into national policies and reverse loss of environmental resources (forests, ozone layer, carbon dioxide). Secondly, reduce biodiversity loss by protecting ecosystems. Thirdly, guarantee the access to safe drinking water and basic sanitation to the largest proportion of population. Finally, improve the life of slum dwellers by developing new facilities or housing and move out possibilities.

Following the MDGs and their relative success, a new framework composed of 17 Sustainable Development Goals [9] (SDG's) was ratified by 193 countries. Approved in 2015, those Global Goals are universally formed and call to action to protect the planet, end poverty and ensure that all societies enjoy peace and prosperity.

Figure 13: 17 Sustainable Development Goals. Source: UN (2015)

"For the goals to be reached, everyone needs to do their part: governments, the private sector, civil society and people like you" (UN home page, 2015).

[9] Accessible online at : http://www.un.org/sustainabledevelopment/sustainable-development-goals/

SDG's turn a step further by presenting more targets and developing new strategies by furnishing strong guidelines and objectives for all countries to adopt alongside their own domestic strategy or taken measures. These goals became effective in January 2016 and provide the direction for the next 15 years in a clear agenda provided by United Nations. The UN obeys a logical continuity by following similar strategies by implementing SMG's. The experience from previous objectives generates a real expertise to achieve this optimistic utopia for 2030. Furthermore, the United Nations insisted on the fact that cooperation & partnership is a precondition for a restored forthcoming of the next compeers.

Some critics have also popped up toward this last Sustainable Development framework. Like their predecessors (MDGs), the SDGs are a statement of aspirations: a voluntary agreement rather than a binding treaty. Even if the agenda is settled and ambitious, it imposes no legally obligations (Thomas Pogge, Yale University). International Council for Science claimed that less than a third of the goals were well developed with some unquantifiable objectives and containing several contradictory trade-offs and unintended consequences[10]. *Euractive*[11] deplored the excessive number of goals. Complex, copious and challenging to implement, other goals may divert the basic needs of poverty, nutrition and education. "*Promising everything to everyone gives us no direction. Having 169 priorities is like having none at all*" (Bjørn Lomborg[12]). It is still too early to draw conclusion to predict the potential success of this framework.

Even if the 11th goal 'Sustainable cities and communities' seems impeccably suited to tackle the development of Shanghai, the environmental aspect of Sustainable Development spread in several other goals. This goal is centered on a smaller scale than the others. Cities or human settlements have to become inclusive, safe resilient and sustainable. Expectations of urban population (urbanization & growth of population) in the future are close to 66% of global population. This phenomenon will be even more impacting in Asia. Sustainable affordable housing, efficient public transport, sustainable use of natural resources, access to water systems and smart urban decisions are needed. In a global development of a city, it is not sufficient to rely only on the 11th goal. This makes rational the assumption of the interconnection of all goals and the necessity to

[10] http://www.icsu.org/publications/reports-and-reviews/review-of-targets-for-the-sustainable-development-goals-the-science-perspective-2015/SDG-Report.pdf online , accessed on 17 May 2017.
[11] European media platform specialising in the online publication of articles focusing on European policymaking
[12] http://www.euractiv.com/section/sustainable-dev/news/sustainable-development-goals-are-not-fit-for-purpose-experts-warn/ online , accessed on 11 May 2017.

tackle simultaneously several challenges or create change across sectors. For instance, cities are advantageously positioned to take on 7th Goal, which calls for improvements in energy access, building efficiency and renewable energy sources. The goal aims to 'ensure access to affordable, reliable, sustainable and modern energy for all', aspiring to double the global rate of energy efficiency advancement.

4.4 Sustainable Development in cities

Cities represent the major contributor of global dioxide emissions; municipalities host more than 50% of world population and two third of total energy use worldwide. These shares are currently growing (OECD, 2009). The United Nations emphasized the issue by publishing a goal focused on city-sustainability. A city is a regional community constituted of the shared integration of the natural, artificial, and socio-economic environment. Due to high density of the population, materials and capitals, space and activities a city is by definition inherent to unsustainability. Therefore, it is necessary to implement the development strategy of eco-city, and it is the most effective way to achieve sustainable development of urban space (Dou & al, 2013). Various intergovernmental instances have tried to provide a specific framework for sustainable cities. Figure 14 exemplifies the reference framework presented by the United Nations in 2003[13]. It symbolizes one of the most complete and entirely adjustable.

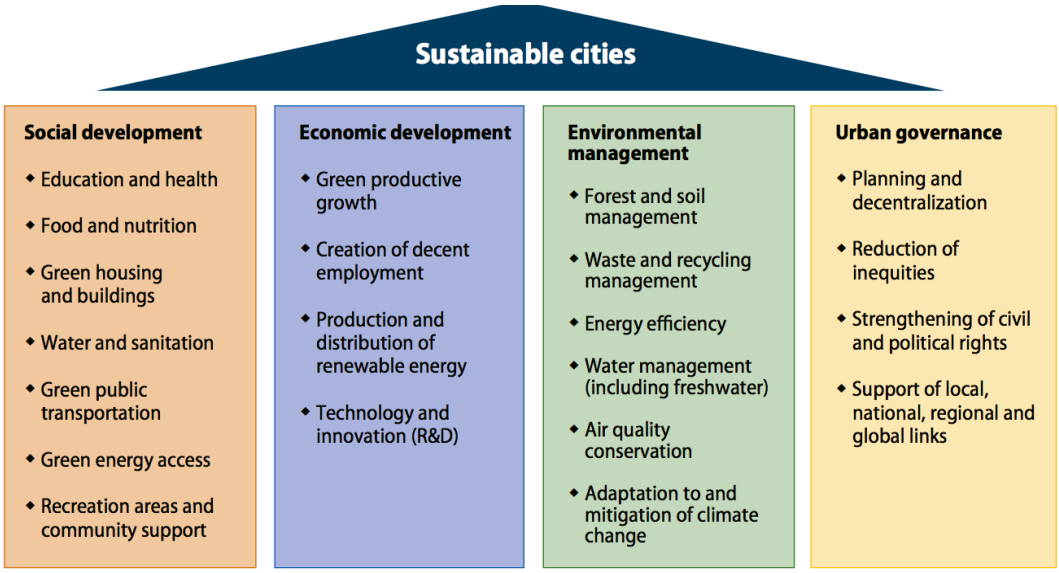


Figure 14: Framework for Sustainable cities. Source: UN (2003)

This framework is mainly based on the 3 pillars previously explained, suitable for any organisation willing to establish sustainable development in large scale. Nevertheless, a next subdivision is added: urban governance. That could explain the sustainable aspect of the city, about planning the urbanization and the rights of local communities. To wholly achieve urban sustainability, a complete integration of the 4 pillars is needed:

[13] Accessible online at http://www.un.org/en/development/desa/policy/wesp/wesp_current/wesp2013.pdf

social development, economic development, environmental management and urban governance. This framework will indicate clearly objectives to attain. It allows planning a certain agenda and a way to validate the consequences. To the extent the city will develop sustainability, it will reflect its ability to customize the concept. It will also provide indications about how far are the measures or the policies taken by the municipality. It is apparent that integrating pillars simultaneously may engender synergies. Water Management as environmental management is the first step to develop water & sanitation as social development. Achieving economically energy efficiency requires high technologies and innovation (R&D) spending. All those potential synergies confirm the feature of interconnectivity among those domains. In most of the cases, investing wisely and consciously in one domain will positively and consequently affect one or several other ones. Understanding this potential advantage may push officials to invest more in some domains.

The United Nations underlines openly the difference between developed and developing countries in term of applying the framework to the policies. Some cities will prioritize some particular policies and measures according to their national, regional or local strategy. For instance, Sao Paulo may invest massive amounts of money in security and order instead of developing recreational areas or forests spaces. High-income city such as Brussels needn't to spend vast sums of capital to provide sanitation and clean water to its total population. An ideal city should invest equally in each pillar; weight of pillar will be considered as dissimilar for each municipality. Therefore, results of policies will evidently depend on the allocation of funds for each pillar (representative of the stage of development of the city), the currently faced challenges and forthcoming challenges.

This thesis focuses on environmental aspect of sustainable development. The section 'environmental management' will be detailed.

4.5 Smart cities and Sustainable cities

Following Paris' agreements[14], the European Union and the United Nations have all together set ambitious climate and energy goals for a near future; there is an urgent need to develop smart solutions to overcome the challenges of urbanization (Ahvenniemi & al, 2017). As clarified before and according to the last UN report, cities can be held responsible for 70% of global emissions. It is observable that cities play a key role fighting climate change and the development of new technologies may be seen as a major driver in decreasing greenhouse gas emissions and improving energy efficiencies. These technologies should not only to be smart, integrated, cost efficient and resource efficient, but also to have deep impact on environmental sustainability and on citizen's wellbeing on the long run.

Both possibilities exist to modify policies: smart city or sustainable city. It exists some doubts and misunderstanding among officials and observers. Recently, policy makers have preferred smart cities instead of sustainable development (Marsal-Llacuna & Segal, 2016). However, both kinds are interconnected and sustainable cities have similar objectives than smart cities and reciprocally. All relies on the current situation of the city, the budget at disposal and particularly the objectives. Even though definitions may differ from place to place, Smart cities can be understood as "*a community in which citizens, knowledge institutions, business firms and municipal agencies collaborate between each other to achieve systems integration and efficiency, citizen engagement and a continually improving quality of life*" (Snow & al, 2016).

Smart cities may be centered into technology around human society. In 2012, most of the smart cities initiatives were located in Europe to support the striving for the ambitious energy efficiency and CO_2 reductions of European Union. Initial target of smart cities, defined as attaining sustainability of a city with help of modern technologies, is not sufficient. Environmental sustainability is an essential pillar to target for smart cities. Sustainable Development is then more complete and suitable for China, especially for the case of Shanghai. Therefore, attention will be focused on "Sustainable city of Shanghai".

There is an increasing interest from the policy makers within the city into the "sustainability" concerns as an important goal and frame of references (Etingoff, 2015).

[14] United Nations - Framework Convention on Climate change ratified by 144 parties accessible online at http://unfccc.int/paris_agreement/items/9485.php

This phenomenon is even unfortunate in China since the beginning of the real perception of climate change. Shanghai tends to auto claim as sustainable city[15] (World Bank, 2012). Due to its rapid industrialization process, China has become the main emitter of carbon dioxide in the world. Consequently, Shanghai similarly considered as the most industrialized city in China is facing serious challenges from harmful emissions and climate change (Li & al, 2017). Shanghai is the pioneer among Chinese cities to reduce environmental impacts. Shanghai municipality has not only been following the directions from Central Government to fulfill national goals for energy intensity and pollution reduction, the megapolis also adjusted its supplementary regulations to achieve this goal. Shanghai decided to become a sustainable city; this will be deepened in the next sections.

Accordingly to the *Bruntland report*, sustainability is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The duality between needs and constraints is contrarious. Hereby, notions of "constraints" are observed; it can be social or technological. Sustainability is broadly understood as a holistic frame for guiding the city's development: "reduce their ecological footprints and resource needs, to deepen connections to landscape and place and to enhance livability and quality of life while expanding economic opportunities for the least-advantaged among others". Moves toward sustainability directly confront resilience feeling. That concept goes along with adaptation following climate change; disaster-resistant or stuck into old fashioned infrastructure or technology.

City managers seem particularly interested in building or adapting into sustainable cities. They are usually facing multiple challenges such as demographic changes, economic constraints, and absence or limited access to the data or metrics to measure the current progress (Corbett & Mellouli, 2017). With responsibility for policy setting, urban planning, built infrastructure and management of natural resources, cities will have undoubtedly a significant impact on the trajectory of Sustainable Development; in other words: the battle of SDGs will be won or lost by the cities. By the clear goals, the United Nations made the definition of Sustainable Development clear to every city in the world. Goals can be perceived as an objective for every municipality by highlighting concrete aims. It is often said that cities have been struggled with converting the fiction into reality. Sustainability notion has been aligned with the United Nation's goals about a range of issues: poverty, gender equality, water, sanitation, energy, public green space,

[15] Sustainable Low-Carbon city development in China, Report of 2012, World Bank

climate peace and change. Transitions to sustainability require a shift to a new trajectory involving changes in socio technical systems, institutions and social groups (Pereverza & al, 2017).

This thesis focuses on environmental aspect of sustainable development. The section 'environmental management' will be detailed. Three aspects will be covered in the next subdivision: energy efficiency, air quality and adaptation to climate change. They stand as challenges for Shanghai. Those challenges have been selected according to the Environmental Management of Figure 14 and the identified problems faced by the municipality (air quality and energy).

5. Main environmental challenges of Shanghai

5.1 Energy in Shanghai

Since 1978, the fast expansion of the Chinese economy has led to significant growth in Chinese energy consumption and greenhouse gases (GHG emissions). Since that period, Chinese energy consumption has been multiplied by 7 and almost 4 times for Shanghai since 1990 (Statistical Yearbook, 2015). Shanghai keeps one of the greatest energy consumption per capita. China became influential in the global energy market due to its increasing energy demand, especially for petroleum and other fuel liquids (CIA Factbook, 2015). However, Shanghai has seen diversification in its energy structure since the decline of primary sector (Hang, 2011). Energy structure can be effortlessly changed at urban level, compared with country level. The urban consumption is more likely to be controlled in an urban policy due to more direct governance (Ru & al, 2010). As China, the majority of energy supply mix of Shanghai is composed of coal and oil. However and especially in this city, the oil proportion is increasing, partially explained by the growing number of cars ownership and the road congestion all over the municipality[16]. Gas contribution remains minor and the electricity represents a larger share each year. Broadly speaking, Shanghai will follow the national strategy. There are several exceptions when officials set some objectives higher than the national ones (Shanghai Environment Bureau, 2015). It will be described in the last section. To prevent climate change consequences, Government of China decided to operate 3 precise goals for a National development plan. All goals stand as a logical suite and are interconnected.

5.1.1 Energy efficiency

Firstly, the country needs to significantly raise the energy efficiency of the whole economy. Decreasing the energy intensity[17] could be a plausible solution (Lin & al, 2004). China has made reducing energy intensity one of the top priorities for the nation and made significant progress in energy saving in the past twenty years. For instance, the 12th National Plan imposes municipalities to decrease energy intensity of 2010 by 20% by

[16] Case Study of Shanghai, accessible at : https://www.worldenergy.org/wpcontent/uploads/2012/10/PUB_Energy_and_urban_innovation_Case_Study_Shanghai_2010_WEC.pdf

[17] As a reminder, Energy intensity is a measure of the Energy efficiency of the country's economy. It is calculated as units of energy per unit of GDP. Energy intensity is the ratio between the Gross Inland Energy Consumption (GIEC) and GDP calculated for a calendar year (European Environment Agency, 2017). For instance, high-energy intensities indicate a high price or cost of converting energy into GDP

2020, around the same percentage for a decrease in carbon emissions (SEPB, 2014). Increasing energy efficiency of the economy through energy intensity could explain partially the weak hypothesis of the EKC. Energy efficiency is often described as using less energy to provide the same service. Energy efficiency improvements in processes and equipment can contribute to notable changes in energy intensity (US Department of Energy). As China has achieved, Shanghai has improved its overall energy intensity; but it remains far from statistics from other western developed countries (Figure 15 & Zumbrun, 2008). To improve energy efficiency, cutting carbon emissions is a possible primary step. It has been performed in the eco building sector for instance (Li & Colombier, 2009).

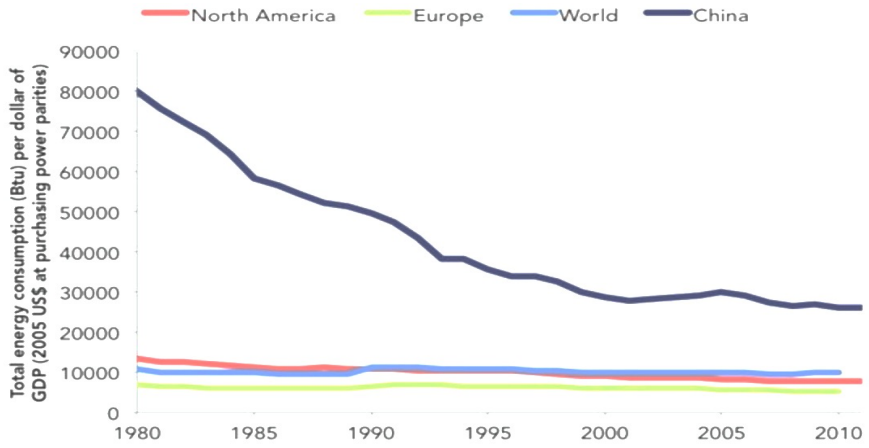


Figure 15: Energy Intensity in China 1980-2010. Source: Smith School for Enterprise & Environment (2010)

5.1.2 Adjustment of energy structure

Secondly, the diversification of its energy structure is an objective. With a growing energy demand, heavy environmental pollution, scarcity of resources and GHG emissions, the development of China has globally attracted attention. Chinese and international scientists have recognized that an appropriate energy strategy is vital if China wants to realize its national target of sustainable development (Ma & al, 2011). Shanghai's energy structure, which heavily relies on coal, creates a significant challenge for carbon reduction. China is actually facing a shortage of liquid fuel and a high dependency on oil imports (BP report, 2012). Global oil production is peaking and the global reserve is still huge but often not economically exploitable (OPEC, 2013). The objective is to lower China's share of coal in its total energy consumption from 64.2% to 62% by 2020 (SEPB, 2014).

The country is also the main producer and consumer of coal all over the world. Whereas it holds the 3rd largest reserve of this mineral resource, China tries each year to decrease its dependency to coal (Global Energy Outlook, 2016). BP has recently estimated the Chinese reserve around 30 years with the current consumption. The nation tries to secure its energy source for the coming years. Abandoning coal consumption represents the first step to decrease GHG emissions and therefore improving air quality in Shanghai (EPA, 2015). Increasing the consumption of gas could also be financially interesting and the potential reserve are massive and rather close (Russia and China) (World Factbook, 2015). Opting for natural gas is a suitable way to reduce significantly GHG emissions. As shown on Table 5, natural gas is primarily methane (CH_4), which has higher energy content relative to other fuels, and thus, it has a relatively lower CO_2-to-energy content (EIA, 2016). Examining emissions, natural gas can be reflected as a cleaner fossil fuel than average fuel and coal. Shanghai may not be completely troubled for scarcity of energy since this province doesn't represent a large energy producer for the country (Chinese Statistical Yearbook, 2014).

Table 5: Amounts of CO2 emissions of fossil fuels.

Type of fuel	**Pounds of CO_2 per Btu**
Coal	228.6
Diesel fuel and heating oil	161.3
Gasoline	157.2
Propane	139
Natural gas	117

Source: EIA (2016)

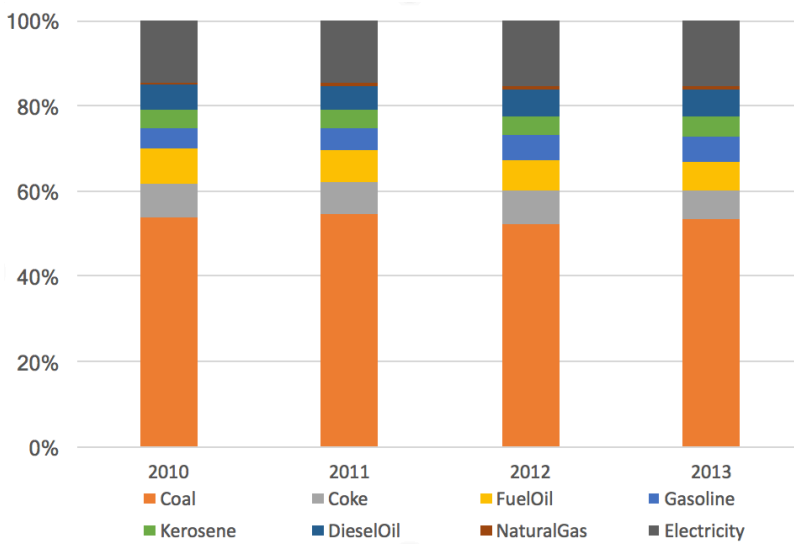


Figure 16: Energy structure of Shanghai 2010-2013 Source: Chinese Statistical Yearbook (2015)

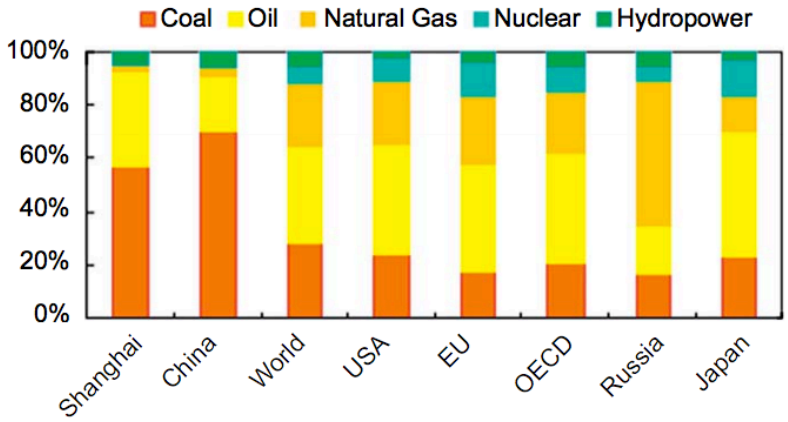


Figure 17: Comparison of energy consumption structure in the World in 2005. Source: Ru & al (2010)

Whereas Figures 16 & 17 display statistics from 2005 and 2013, numbers have since then slightly changed but the overall trends remain unaffected. Since 2000, electric power increased its share every year. Shanghai is facing a massive and growing oil dependency. Figure 18 confirms that Shanghai structure is slightly different than Chinese one, the consumption of coal is less important for Shanghai and it is counterbalanced by its oil reliance. A significant difference is observed in the predominance of coal in China and other countries.

5.1.3 Renewable energy share

Lastly, the finishing objective is to develop sustainable and cleaner forms of energies. That comes along with a diversification of energy structure. The renewable energy in China has great potential for development. Broadly speaking, an ideal diversification should be leaving fossil fuels toward renewable energies. China is far from this complete diversification. It is too premature to use renewable energy as main energy supply (Liuyijun, 2011). However, in the end of 2012, China had the highest capacity of renewable power in the world and approximately 20% of the electricity demand in China was met by renewables in 2012. China is also one of the top countries for solar heat capacity of all types (Renewable Global Status Report, 2013). According to IEA in 2014, the share of renewable electricity production peaked at 23.02%. In 2015, China was the country, which invested the most in renewable energy [18] projects all over the world [19]. It exists five commonly used sources: biomass (includes wood, municipal solid waste, gas, ethanol and biodiesel), hydropower, geothermal, wind and solar.

As formerly enlightened, 23.02% of the global generation of electricity in China comes from renewable. It is imperative to observe that 81.40% comes directly from hydropower. There are no significant power stations located in the area of Shanghai. Cities usually consider risky to rely on heavily hydropower. Some ecosystems and water shortage may arise upstream the delta (Vancouver case, 100% renewable Energy goal, 2015). Shanghai area faces a shortage of primary mineral resources. Coal and oil used for power generation need to be imported from other provinces. This could be the same for electricity from Hydropower, and electricity in general. China is gifted with an abundant reserve of renewable energy sources that are presently under-exploited, offering substantial opportunities for renewable energy system expansion and environmental sustainable alleviation of its reliance on fossil fuel (Cherni et al, 2007). A solid residential and industrial waste management could also become an easy source of energy for Shanghai (Ward et Li, 1993).

Energy structure optimization is an indispensable and long-term method to achieve carbon emissions reduction. Shanghai is also implementing a strict policy of energy efficiency in urban management; especially in building sector (Chinese government,

[18] As an aide-mémoire, Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat (Ellabban & al, 2014).

[19] Report of Global Trends of Renewable Energy Investments of UNEP 2016 http://fs-unepcentre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2016lowres_0.pdf

2004). As a post-industrial city in China, Shanghai should actively build a diverse and efficient energy supply and consumption system with the characteristics of environment and climate friendly (Ru et al, 2010). It is obvious that Shanghai cannot produce all its daily energy need due to its massive consumption and the absence of production facilities. Much of the necessary changes to meet these goals in urban context will come through new and renewable energy technologies combined with energy efficiency. It is not only developing clean energy resources. Diversification of energy is a gradual necessity and keeping in mind the Energy Trilemna as shown on Figure 18 (balance between the sustainability, the equity and the security of energy supply) is compulsory (ARUP, 2013). Improving energy efficiency is a potential first step. As a heavy urbanized area, Shanghai is already developing low carbon buildings and therefore energetic performance and adaptation to climate change (World Bank, 2013). Shanghai has also applied several measures to improve its transport system (UN, 2014).

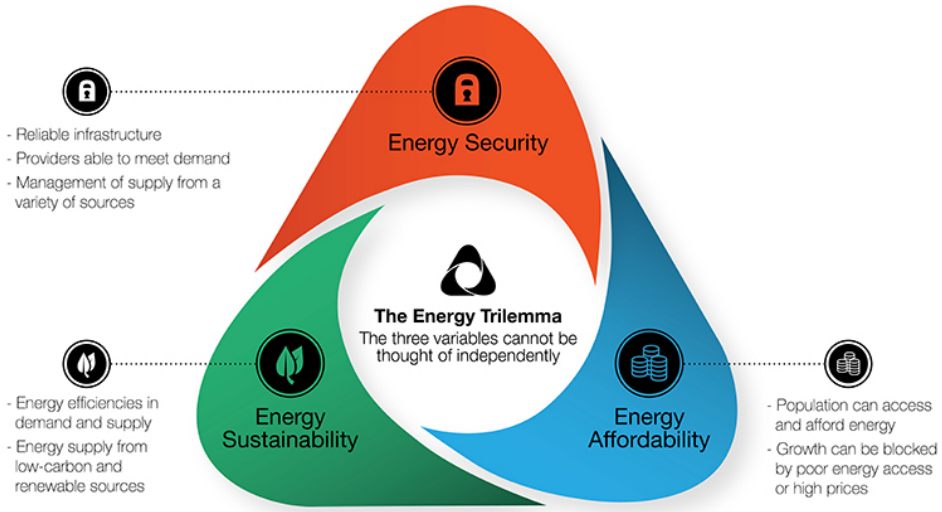


Figure 18: Energy Trilemna. Source: ARUP (2013)

5.2 Air quality in Shanghai

Large volumes of energy and resources have been consumed in China since 1978 to maintain the rate of Chinese economic development. Fast motorization has contributed to environmental problems including urban air pollution (Huang et al, 2017). Consequently, numerous Chinese cities have been among the most polluted cities in the world. More than one billion Chinese people are exposed to air quality considered unsafe for more than half of a year. Shanghai's air quality is facing a particular situation due to the rising number of vehicles in the city, various construction projects across the city and several different atmospheric factors (Shanghaidaily, 2016).

According to a study of Shanghai's universities (Yang, 2014), air pollution is attributed to different actors (cfr Table 6). Measures can be taken more precisely into specific sectors. Table 6 indicates another problem. Shanghai is suffering from air pollution from outside the city. In theory, Shanghai municipality cannot interfere meanwhile it accounts for more than 20% of overall pollution. In most rural areas – especially in Mainland China – the energy and industry sectors, as well as wood cook stoves, dominate air quality. As the traffic accounts for a large proportion of air pollution, another challenge is improving the situation of road congestion (Lu et Li, 2009).

Table 6: Air pollution Shanghai composition in 2014

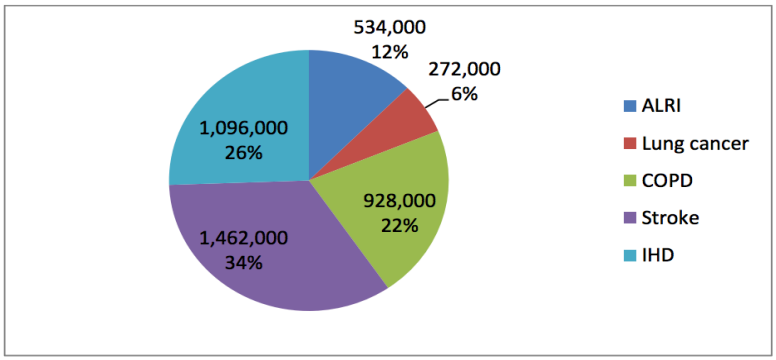
Emissions from industrial plants in Shanghai	32.9%
Motor vehicles, ships and planes accounted	25.8%
Dust, cooking and the agricultural sector	19.8%
Pollutants from outside Shanghai	**21.5%**

Source: Chinadaily (2014)

Shanghai is taking seriously this phenomenon of air pollution for several reasons. It is not only for the environmental aspect of sustainability but also a direct source of health issue for the population. According to the World Health Organisation, air pollution has become the world's single largest environmental health risk, linked to around 7 million – or nearly one in eight deaths in 2012[20]. As in Figure 19, several diseases as a direct consequence in households of air pollution may appear. 40% is tightly linked with lung problems. Children, women, the elderly, and the poor are the most vulnerable groups.

[20] http://www.who.int/phe/health_topics/outdoorair/databases/FINAL_HAP_AAP_BoD_24March2014.pdf?ua=1

Secondly, air pollution is also a direct concern of increasing road network and vehicles. More than 80% of people living in urban areas that monitor air pollution are exposed to air quality levels that exceed WHO limits. While all regions of the world are concerned, mostly population in low-income cities are impacted. Ambient air pollution is one of the major environmental problems in China, leading to 157.3–519.9 billion Chinese Yuan loss in 2003, which accounted for approximately 1.2%–3.8% of China's Gross Domestic Product (World Bank, 2007).



Percentage represents percent of total HAP burden (add up to 100%).
HAP: Household air pollution; ALRI: Acute lower respiratory disease; COPD: Chronic obstructive pulmonary disease; IHD: Ischaemic heart disease.

Figure 19: Death Attributable to HAP in 2012, by disease. Source: WHO (2012)

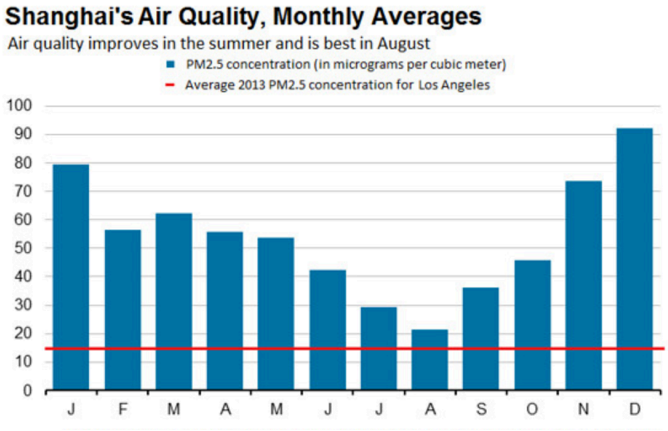


Figure 20: Shanghai AQI 2014. Source: WJS (2014)

Air pollution is usually measured by AQI (Air quality index) or API (Air Quality Program) and composed of several average quantities of particles in air during the year. According to Chinese Statistical Yearbook, air quality is generally better every year in

Shanghai. Even if the average number of PM2.5 (particles from 2.5mm present in the air hazardous for the body) is higher than most European standards, this rate could be considered as low in comparison with other large cities of other emerging cities (Mexico or Mumbai). On the ranking of WHO, Shanghai presented an annual average of 59 PM in 2015, therefore Shanghai is seen as 239th (3000 different towns in 103 countries[21]). This represents an optimist overall score for the Megapolis. It is explained by the absence of heavy industries and a developed public transport offer. In the State of the Environment Report of 2013, it revealed that only 4.1% of the 74 surveyed cities met the new standards for PM2.5 emissions. The concentration of PM2.5 is of great importance to protect human health and control air pollution in Shanghai. While there are limited air-quality monitor stations in a city, air quality varies in urban spaces non-linearly and depends on multiple factors, such as meteorology, traffic volume, and land uses. Shanghai has therefore developed an intense network of air monitoring stations and an efficient air pollution alarm system (Zheng et al, 2013).

As an illustration, Beijing is far more concerned about this air pollution level; currently considered as the 11th Chinese city or 57th globally. It is important to note that air pollution in Shanghai is not exactly stable, Shanghai being close to the ocean benefits from heavy wind (cfr Figure 20). Consequently, Shanghai is more polluted in winter than in summer due to the presence of wind blowing and spreading the particles away from the city center. Some people argue that it the reason why Shanghai doe not seem to be over polluted according to pollutants measures. This explanation cannot apply in Beijing; its pollution remains stable all over the year.

[21] http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/

5.3 Adaptation to climate change in Shanghai

"Adaptation means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause, or taking advantage of opportunities that may arise. It has been shown that well planned, early adaptation action saves money and lives later"

European Union[22], European climate action

Basically, there are two main policy answers to climate change: mitigation and adaptation. Mitigation tackles the main origins by decreasing GHG emissions. Adaptation tries to lower the risks posed by the consequences of climatic changes (Nasa – Global Change Institute). Both approaches have to be applied simultaneously. Human society is too far in the climate change process to rely only on adaptation (Verchot et al, 2007). Adaptation policies may be planned in advance or put in place suddenly in response to a sudden specific burden. Broadly speaking, adaptation is a shared and common responsibility. Different layers of power are directly involved. Governments at all levels, businesses and households have complementary roles to play. Individuals and businesses will often be best placed to make adaptation decisions that reduce climate risks to their assets and livelihoods (Nyong et al, 2007).

Humans have been adapting to their surroundings throughout history by developing practices, cultures and livelihoods suited to regional situations. Nevertheless, climate change brings the likelihood that current civilizations will experience climatic shifts (storm frequency, temperature, see level, flooding and various other factors) that previous experience has not prepared them for (Coop et al, 2009). A suitable illustration for the Chinese society is the direct adaptation to the Smog in Shanghai. The city adapts to it by maintaining red alert; it means closing schools, universities, public services and discourage the population being outside. In the same time, as mitigation measures (getting rid of GHG emissions), officials decided to tackle the problem by closing suddenly heavy polluting factories, disrupting air traffic, port traffic and diminish road congestion (Reuters, 2016). It confirms that Chinese government uses both tactics following climate change.

Recognizing consequences of climate change is a great first step for the future. Then, an optimal balance between mitigation and adaptation should be settled. As explained before, a subtle combination of both is needed to optimize the short term and the long

[22] https://ec.europa.eu/clima/policies/adaptation_en

terms results. Beside that, allocation of resource to adapt our society remains particularly crucial (Sovacool et al, 2017). Once the solid plan is settled down and undoubtedly scheduled, the next complex problem remains the financing of this change. The allocation of the budget (mobilized capital to achieve the objectives), the institutions that will apply those measures, all those questions need a precise answer to be efficient for the country (Fridahl & Linnér, 2015).

China has also problems with willingness to adapt. Impacts posed by climate changes on existing infrastructures or people seem too gradual or moderate to be seen as serious and recurrent. If there are no incentives to change, why changing and leaving a situation in which there are benefits? China has confronted the situation in its ports all over the coastline. Rise of the sea level will not affect the harbour infrastructures and other river ports according to Chinese officials (Experience of Chinese Ports in adapting to climate changes, Hong Kong University conference, 2011). Being the most populated country and the second giant in the global economy, China's response to the impending effects of climate change is of great concern for the entire world. The answer has been under scrutiny of several international observers. China is both the world's largest exporter of renewable energy, and at the same time one of the leading exporters of coal-fired power plants (The Guardian, 2016). People tend to believe that China has been neglecting Climate change. In a study of Gotenborg University about WTP (willingness to pay) in 2010, Chinese people were less neglecting global warming than the Americans (Carlsson et al, 2010).

Shanghai has faced two major challenges with Climate change. Firstly, Shanghai has to deal with local climatic effects due to rapid large-scale urbanization in a short period of time (land pressure, air pollution, growth of population) (Cui & Shi, 2012). Secondly, Shanghai is similarly facing climates changes (heat waves, air pollution, rise of sea levels) associated with global warming (Li et al, 2017). This makes the situation of this Mega-city even more interesting; the municipality has to conduct itself toward two diverse troubles. Shanghai with its tremendous population and fast urbanization is considered as the most vulnerable port city in China if damaging climate change is out of control. Yangtze river represents 40% of Chinese freshwater resources (WWF, 2005). Finding a balance between economic development and environmental concerns is a great challenge to preserve this homeland for fisheries activities, agricultural resources (grains and grains), lakes and urban settlements. Climate change may continue to menace Shanghai's

economy and ecosystems, affecting its transportation, investment and insurance, tourism and biodiversity. Several Yangtze forums were organized to plan environmental management and preservation of this whole area (Cui & Shi, 2012).

After the explanation of those challenges, the next section will describe Chinese environmental governance with a comparison of Chinese national goals and Shanghai ones. This closing section will explain how concretely Shanghai has adapted its policies in relation with those challenges and the concept of sustainable development without compromising the economic development.

6. Environmental policy and governance for Shanghai

6.1 Chinese environmental governance.

To comprehend Shanghainese environmental governance, it seems crucial to describe the distinctive national plans of China. All local levels (province and cities) need to trail the same nationwide guidelines; it is common in some sectors to develop supplementary objectives or ratify stronger specific measures (Liu & al, 2012). Five-Year plans are a sequence of social and economic development initiatives shaped by Communist Party of China since 1953. It delivers a clear national strategy and intention, and it is vital for boosting the management and implementation of the nation (Hu, 2016). Chinese environmental governance is defined as an evolutionary process and strictly planned. Environmental targets are continuously adapted according to previous achievements, failures and scientific researches (Mol & Carter, 2006). As a centrally planned economy, officials decided to include environmental concerns since the 10th Five-Year Plan.

The 10th Five-Year Plan (2001-2005) was ratified in 2000[23]. For the first time in Chinese economic development, actions concerning environment were highlighted. *Shi Dinghuan*, official from Ministry of Science and Technology of China has claimed in 2000[24] that China and the rest of the world are facing two problems: serious environmental pressure and energy resources shortages. The Chinese government decided to pay more attention on development and use of the renewable energy following the United Nations Conference (Global Environment and development held in 1992). Focus was agreed on conversion efficiency of energy, cutting down production costs and increasing share of renewable in its energy supply structure. Massive amounts (around $20 billion in 5 years) in R&D have been invested in different projects in renewable energy during this plan. Several governmental departments have agreed to cooperate and took efficient measures: lay down development plan and ensure vital financial resources, provide support on policy and finance, support on speeding up the industrialization process, establish a well-

[23] http://www.china.org.cn/english/MATERIAL/157629.htm - Detail of 10th Five-Year Plan
[24] http://frankhaugwitz.com/doks/general/2000_08_06_China_RE_10_Five_Year_Plan_MOST.pdf - Interview conference

organized subdivision of scientific research, and enhancing international collaboration by introducing innovative technologies or financial aids. Environmentally, the 10th plan could be considered partially achieved but significant progresses have been observed: major pollutants have been reduced (industrial dust, solid waste, COD). However, SO_2 emissions did not meet the expectations, it augmented around 30% (Ball State University, 2011).

Afterwards, the 11th Five-Year Plan[25](2006–2010) was submitted in the National People's Congress session. In a country where the state continues to exercise powerful control over most of the economy, Chinese leaders were seriously rethinking their development priorities and strategies (Fan, 2006). Additionally, environment took a major role in this plan with more technical measures than previous plans.

This plan sets an ambitious target for energy efficiency improvements: energy intensity of the GDP should be reduced by 20%. Hereby, the weak concept of sustainable development can be observed, by focusing on relative improvements. This is the first time that a quantitative and binding target has been settled for energy efficiency. That illustrates clearly a major shift in Chinese strategy about its long-term economy and energetic development (Lin & al, 2007). Energy and environmental objectives in this plan are ambitious and will require significant labours on several levels. Great efforts have been made to eliminate backward production capacity and popularize new technology for energy-saving and emission cuts. Consequently, the 20% reduction of energy consumption has been achieved (China.org.cn, 2011). The 11th plan performance was respectable in term of energy consumption, CO_2 emissions and energy efficiency. However, China should stimulate more policy support to economic restructuring and development of renewable energies (Xu & al, 2014). Simultaneously to the 11th plan, other local and provincial government entities prepared more detailed Five-year plans (Cao et al, 2009). Entities usually apply national goals and set new customized objectives according to their own needs. Shanghai's governance, inaugurated in 1999, will be illuminated later on.

Then, the 12th plan was sanctioned (2011-2015)[26]. This plan is perceived as a turning point from the country's former prominence on growth: representatives are now

[25] http://www.gov.cn/english/2006-03/06/content_219504.htm - Detail of 11th Five-Year Plan
[26] https://www.wlstorage.net/gifiles/attach/11/11799_KPMG%20om%20China-12th-Five-Year-Plan-Overview-201104.pdf - Key points of 12th Plan from KPMG China

highlighting approaches to ensure long-term prosperity on the national scale (KPMG, 2011). Following Copenhagen Summit[27], China decided to reduce emissions intensity of GDP in 2020 by 40 to 45%. This decision is historically a first step to acknowledge Chinese responsibility for CO_2 emissions and vital measure to avoid putting a spoke in developing countries' wheels (Lu & al, 2012). China reinforced its effort to reduce the emissions intensity of output by setting a reduction target of 17% by 2015. The plan also included an energy intensity target (a reduction in the ratio of energy consumption to GDP of 16 % by 2015, relative to 2010), and a renewable energy target (an increase in the contribution of non fossil fuel sources to energy consumption from 8.4 to 11.4% by 2015). Importantly, the plan refers to the establishment of market mechanisms to help encourage energy efficiency (Lu & al, 2012). The Concept of sustainable development appeared for the first time in Chinese economic development; not only about environment but also with a recognizable social aspect or human condition[28] (Sustainable development – Knowledge Platform- United Nations, 2010). Several themes in environment were covered: protecting the environment and improve the energy efficiency, sustainable growth (energy savings, natural resource protection, new energy & clean energy vehicles). Seven identified priority industries will be developed: renewable energies (nuclear, wind and solar power), energy conservation, environmental protection and clean energy vehicles (fuelled by natural gas or electrical). This plan also settled the goal of 'carbon trade market'. This trade was not cautiously elaborated (Lin & Sun, 2010). A handful of provinces have announced interest in piloting carbon-trading schemes (Lewis, 2011). China has seen major achievements in environment: the revised Environmental Protection Law[29], air quality (closing of illegal heavy polluting factories, new energy vehicles, public smog attention), water (reduce pollutants and protection of drinking water), natural protection (control of pollution of soil with pesticides, heavy metals or organic pollutants), and clean energy (increasing investment in renewable energies and nuclear and optimistic results for emissions and reduction of consumption) (Chinadaily, 2015). The 12th Plan has promoted cooperation between the government and the market, and the central with the local governments. These interactions will

[27] The 2009 United Nations Climate Change Conference, commonly known as the Copenhagen Summit, was held in Copenhagen in December. A framework for climate change mitigation beyond 2012 was to be agreed there by the COP 15.

[28] https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=700&menu=1515 - APCO worldwide report of 12th plan in China.

[29] The law adopted in 2015 increased the responsability of local governments to deal with environmental problems by giving them unprecendented power (accumulted fines, zero tolerance, demoted local officials for misconduct or falsifying data)

continue to guide the world towards further green development and make massive green contributions to the humanity (Hu, 2016).

Finally, the last and current national plan is presented: 13th Five-Year Plan (2016-2020)[30]. Most of the 13th Five Year Plan's energy and environment measures are removed from the Energy Development Strategy Action Plan 2014-2020, and the Environment Protection Law (The Economist, 2016). It is a clear statement of intent to dominate clean technology markets home and abroad. The plan accelerates Chinese move into the low carbon economy; creating a strategic challenge for European economy. The plan aims to dominate global clean energy markets (NG & al, 2016).

It focuses on several areas such as innovation, low carbon industry (green finance and green development funds), stricter management system for water resources, national real time monitoring system to evaluate performance, emission permits and forest protection. Climate targets are defined reducing carbon and energy intensity by 18% and 15%, increasing investments in clean energy (non fossil power generation), significant reduction in coal and development of clean vehicles. The 13th Five-Year Plan includes, for the first time, a "binding" target for the reduction of PM 2.5 levels of air pollution (The Economist, 2016). It is still too early to draw conclusions about the potential achievements on 13th plan, however the potential and the previous results seem positive for the future (Mizuho Bank report, 2016)

Table 7:Main policies targets for National Plans of China.

Targets	**10th Plan (2005 target)**	**Actual 2005**	**11th plan (2010 target)**	**Actual 2010**	**12th Plan (2015 target)**	**Actual 2015**	**13th plan (2020 target)**
Reduction in Carbon Emission per unit of GDP	-	-	-	N/A	17%	20%	18%
Non Fossil Fuel as a percent of primary energy consumption	-	-	-	8.30%	11.4%	12%	15%
Reduction in energy intensity per unit of GDP	24%	N/A	20%	16%	16%	18.2%	15%
Reduction of emission from major pollutants[31]	-	-	-	-	9%	15.16%	12.5%
Forest coverage	18.2%	N/A	20%	20.36%	21.66%	21.66%	23.04%
Air Quality Ratio days a year with Level +	-	-	-	-	-	76.7%	>80%

[30] http://news.xinhuanet.com/english/photo/2015-11/04/c_134783513.htm - Key points of 13th Five-Year Plan.
[31] Calculated average of COD, CO_2, Ammonia Nitrogen, Nitrous Oxides

Reduction of PM2.5	-	-	-	-	-	-	18%
Water Quality (% of water exceeding Level +)	-	-	-	-	-	66%	>70%
Comprehensive rate of Industrial waste	4.3%	N/A	4.2%	69%	-	-	-

Source: US Government in China (2015)

On Table 7, a summary of main environmental policies since 2000 within the different national plans is presented. The reference year is the year just before the next plan. It confirms the continuously aspect of those plans. It usually adjusts targets according to previous achievements. Shanghai has followed by some means the same direction than the national plans but some policies have been settled earlier (PM2.5 or SO_2 emissions). However, inspecting the 3 main challenges of Shanghai, national plans may moderately differ. As previously explained, China included the whole sustainable development concept from the 12th Plan (including a social aspect to the economy and the environment). In terms of energy, measures to increase share of renewable was also taken by Shanghai in its adjustment of energy mix. Other measures in the transformation of Chinese industry toward a service economy follow the same route. Reduction in energy intensity will be also in Shanghai's measures.

For China, air quality was improved since the 12th Plan with the reduction of PM2.5 and the increase of the average days a year. Carbon reductions only appeared in 2015.

In the next and final section, both national and Shanghai will be compared. Different trends and policies from Shanghai will be analysed.

6.2 Shanghai Environmental policy plan

This section will answer to the research question: *how did Shanghai adapt its environmental governance to maintain its economic growth*? How did Shanghai incorporate the environmental aspect of sustainable development concept in its governance?

Being firstly concerned with the environment in China, Shanghai launched its first Three-year Environmental Action Plan to tackle environmental protection in 2000. As a reminder, the first National plan with environmental concerns appeared one year later. This plan was about 5 principal categories: rehabilitation of aquatic environment, improvement of atmospheric environment, disposal of solid waste, urban greening and environmental rehabilitation in industrial zones. In 2001, China acted similarly in its 10th National Plan and the metropolis created an explicit Key Action Plan by including both national and local goals for the Expo 2010[32]. After the founding of Shanghai Environmental Protection Committee, SEP Bureau was instituted in 2003. With the support of United Nations Development Programme (UNDP) and UNEP (United Nations Environment Protection), the project of "Building Shanghai as an Environmentally-Friendly City" was officially presented in 2005.

Table 8: Progression of Three-Year Plans of Environmental Protection.

1st	2nd	3rd	4th
2000-2002	2003-2005	2006-2008	2009-2011
Aquatic Environment Rehabilitation	Aquatic Environment Rehabilitation	Aquatic Environment Rehabilitation & Protection	Aquatic Environment Rehabilitation & Protection
Ambient Air Pollution Control	Ambient Air Pollution Control	Ambient Air Pollution Control and Protection	Ambient Air Pollution Control and Protection
Disposal of Solid Waste	Disposal and Utilisation of Solid Waste	Disposal and Utilisation of Solid Waste	Noise Pollution Control + Disposal and Utilisation of Solid Waste
Green Space development	Green Space development	Industrial Pollution Control, Cleaner Production and Circular Economy	Prevention and Control of Industrial Pollution
Comprehensive Environmental Rehabilitation in Wusong & Taopu Industrial Zones	Comprehensive Environmental Rehabilitation in Major Industrial Polluting Enterprises & Industrial Zones	Agricultural Pollution Control & Rural Environment Protection	Circular Economy & Cleaner Production

[32] The Expo 2010 was held in Shanghai, China, from 1 May to 31 October 2010. The theme of the exposition was "Better City – Better Life" and signifies Shanghai's new status in the 21st century as the "next great world city". Shanghai has seen major improvements in public infrastructures to host international visitors and investors to contemplate the new innovative face of China. Debt of World Expo has been evaluated at $55 billion, twice as much as Beijing Olympics (Waldmeir, 2010).

	Ecological Conservation and Environmental Infrastructure Construction in Chongming County (Island)	Agricultural and Rural Environmental Protection
		Ecological Conservation and Construction

Source: SEPB (2010)

6.2.1 Budget

Budget is an important prerequisite to implement policies and measures. Shanghai has inaugurated with SEPB an environmental management system with high efficiency, to improve its management competences and to generate a prototypical example with the Expo (UNEP Report of 2010). As China performed in the different National plans, Shanghai put in place a succession of plans; it is similarly seen as an uninterrupted and evolutionary process. Table 8 presents explicitly this continual enlargement of objectives according to achievements and failures. Beside, table 8 demonstrates a surprising phenomenon. The 3 core challenges of Shanghai previously described are: energy (efficiency, adjustment of energy structure, sustainable energy), air quality and adaption to climate change. Except the Air quality, the two others are not clearly pointed in the different Three-Year plans. Shanghai has therefore followed the national direction of structural adjustment. Shanghai has been adding simultaneous specific plan (in industries, or air quality). Differences will be highlighted later on.

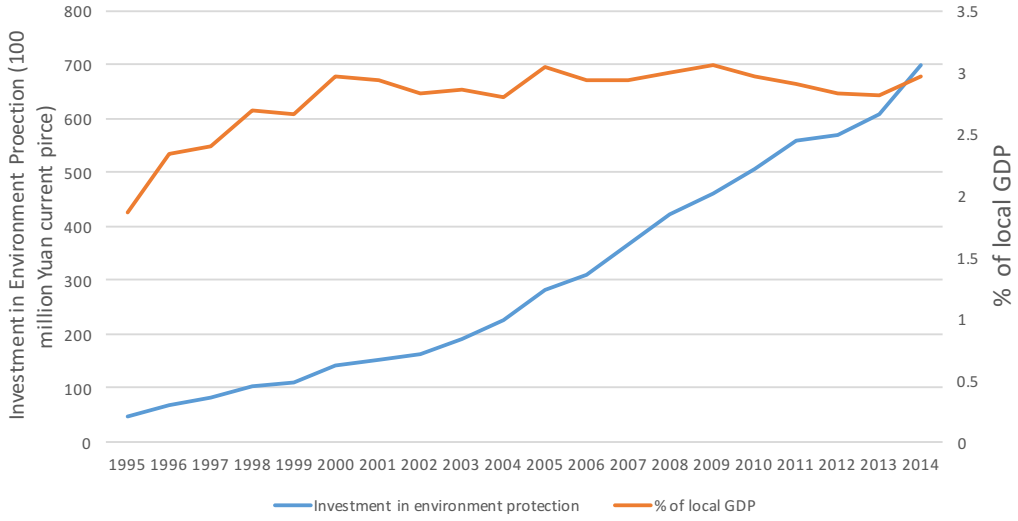


Figure 21: Investments in Environmental Protection and percentage of GDP of Shanghai from 1995 to 2014
Source: Chinese Statistical Yearbook (2015)

Environmental aspect is a major pillar of sustainable development concept within a city. Shanghai decided to allocate a growing share of the budget. On Figure 21, investments in environmental protection in Shanghai from 1995 to 2014 are observed. The relative amounts invested are increasing. 3% of the local GDP allocated to environment seems to be the positive limit reached by the municipality. The peak (3.06%) has been spotted in 2009; it could be explained by larger sums of money spent before the Expo 2010 to attain significant results. On Table 9, the different allocations of the input in environmental protection can be spotted.

Table 9: Expenditures in total input for environment protection.

Expenditure item	**Billions ¥**	**%**
Construction of Urban Environmental Infrastructures	24.66	34.90
Renovation of Pollution sources	25.029	35.30
Ecological protection and construction	0.599	0.80
Environment Protection in rural area	6.093	8.60
Promotion of environmental management	0.645	0.90
Operations facilities for Environmental protection	13.187	18.60
Input for circular economy	0.665	0.90

Source: SEPB (2015)

6.2.2 Energy scheme

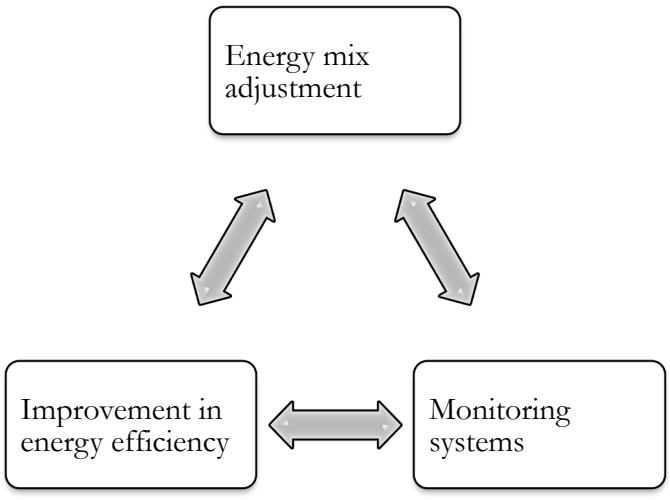


Figure 22: Energy Scheme Shanghai. Source: SEPB (2015)

This scheme was undoubtedly the first necessary base for subsequent measures (cfr Figure 22). To be exemplary for the Expo 2010, Shanghai decided to tackle the problem of energy in 2 main pillars (Environmental Report for Expo 2010 Shanghai China, 2010). Shanghai has decided to slowly move GDP structure toward a strong tertiary sector by withdrawing heavy polluting industries (the municipality decided to close down some factories - 6.2.3 will detail concretely how Shanghai manage to transform its economic structure) and developing a modern service industry. Shanghai found inspiration of this scheme in the National plans. How did Shanghai adapt its energy strategy to the local demand?

Firstly, Shanghai had to optimize its energy structure. As explained before, reducing coal consumption (from 65% in 2000 to 51.3% in 2007), increasing share of cleaner energies (natural gas and electricity), and developing renewables infrastructures (solar and wind) were the possible paths to succeed. Shanghai was the pioneer city in the world to develop with World Bank a "Green Electricity Scheme" (Energy Sector Management Assistance Program ESMAP, 2006, "Shanghai: developing a Green Electricity Scheme"). Several successful projects of green electricity production were settled (cfr "Green Energy Schemes for Low-Carbon City in Shanghai China, World Bank). Structural adjustments were performed in old industrial areas such as 'Basically Zero Coal Burning Zone or Flying Dust Controlled Zone'. Several rehabilitations of industrial zones and renovations of fuel-based infrastructures were completed. Then, different policies were put in place to compensate the cost of cleaner electricity by subsidizing and awarding some deserving enterprises. For instance, Shanghai efficaciously finalized several projects of desulphurization and denitration in large power plants. Shanghai augmented subsides to replace hundreds of kilns and coal-fired boilers toward cleaner apparels. If some enterprises did not meet the requirements, Shanghai closed deliberately some plants.

Secondly, improvements in energy efficiency were encouraged alongside the national target of energy conservation and emissions reduction. Shanghai abridged strict access to new industries with high-energy consumption coupled with a low added value. Shanghai accelerated modernization of existent enterprises (1500 from 2005-2007). Shanghai has improved gross consumption volume of primary energy sources in industry, construction and transports (EIA, 2016). The Municipality has conducted several controls on energy conservations and emission reduction programs. Shanghai modified the energy efficiency, notably in the construction sector.

In the same time, control of pollutants was also emphasized. Shanghai has developed various promotion mechanisms, statistics monitoring and evaluation systems trough industrial restructuring with projects and management progresses. This advanced procedure allows bureaucrats to inspect closely daily results and consequently taking prompt and deliberated penalties to identified polluters. Shanghai controls the daily pollution or environmental degradation via large numbers of monitor systems. SEPB can enforce new policies or giving fines to reluctant actors. This heavy modification has allowed significant improvements in other sectors.

6.2.3 Concrete measures

The construction sector represents a large share of energy consumption and for the residential consumption. Due to the National goals, energy efficiency in the construction sector was tackled in 2006. The municipality has augmented the requirements of energy use in industrial, commercial and residential buildings. Using green building techniques could save up to 50% of energy (US consulate in Shanghai, 2015). Efforts will be conducted in 3 different layers: the building envelope (roof, wall, windows and foundations), air systems (heating, ventilation and air conditioning systems) and the inside appliances (lighting, cooking and other appliances) (Cheng & al, 2014). Shanghai additionally hosts several skyscrapers; which characterize a real illustration of modern green building. Government wants 30% green construction projects by 2020 (Roxburgh, 2016).

Since 2005, air quality followed a steady improvement curve (from 88 to 91.5%). The dropping amount of inhalable particles (SO_2, NO_2, acid rains and dust falls) confirms this improvement in air quality. Due to the health issues and the smog, Shanghai has often put stricter regulations than overall China. Shanghai has used several measures to improve the air quality such as FGD [33] in coal-fired power stations gasoline desulphurization for vehicles emissions, boilers replacements or dust-filter on chimneys. Air quality became the leading priority: the new "Clean Air Action Plan" was presented: reducing amount of PM2.5 of 20% by 2017 compared to 2012 (Dong, 2013). The city mainly modified the air quality by regulating the industry (emissions and technologies) and transport (polluting vehicles, cleaner energies, expanding public offer).

[33] Flue-gas desulfurization (FGD) is a set of technologies used to remove sulphur dioxide (SO_2) from exhaust flue gases of fossil-fuel power plants, and from the emissions of other sulphur oxide emitting processes. It follows 11th National Plan and allows decreasing air pollution.

Shanghai emphasized water management due to its coastal location. Shanghai developed several plans focused on projects improving water environment: sewage treatment, creation of canals and intensive water supply pipeline, recycling industrial water and several others. Shanghai began fighting noise pollution, which is not the case in the National plan. It helps to reduce road congestion -one of the major cause of noise- and complaints of inhabitants (Kun & Yingying, 2013). The city imposed strict regulations on residential, solid and industrial waste; and controls on several sectors heavily polluting such as chemical industries. Whereas agriculture doesn't represent a large share of economy, the municipality strengthened the use of fertilizers and other chemicals on crops. Shanghai also focused on environment protection. Number of reforms in rural villages and projects on ecological protection (green space, forest coverage) botanical gardens, and ecological reserves) increased overall the province.

As a city, Shanghai highlighted heavily Circular economy projects[34] and Low-Carbon economy[35]. Shanghai decided to include this first concept in 2006. Low carbon projects were developed in an eco island (ecological protection and recycling energy in Chongming), manufacturing industry in Lingang Industrial Park and a service industry in Hongqiao. Low Carbon concept existed also in the 12th National Plan and those projects are real large-scale illustrations that the existent economy (composed of natural reserves, manufacturing and service industry) can be turned into this concept.

The Expo in 2010 characterizes a first shift toward environmental protection. The municipality wanted to rearrange the site of The Expo to turn it as an example for an eco-environment. Coverage rate of green spaces of the Expo site was above 50%, 80% of remaining pavilions were transformed into roof-vertical-internal greening space, photovoltaic systems were developed in the expo garden, LED technology was spread all over the site, roads were made from debris of demolition, pavilions were easy to dismantle and erected with environment friendly materials. SEPB estimates the rate of clean energy around the site above 50%.

To reach a better air quality, it became necessary to regulate the transport. Road congestion is problematic in Shanghai and represents also a main contributor to emissions. Modifying transport is an instance of mitigation toward Climate change.

[34] Circular economy can be defined as a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. The concept was formally accepted in 2002 and included in the 10th National Plan by the Central Government as a new growth strategy which aims to ease the paradox between fast economic development and the scarcity of raw materials or energy (Yuan & al, 2006).

[35] A Low Carbon economy, also called low-fossil-fuel economy or decarbonised economy is an economy based on low carbon power sources that therefore has a minimal output of GHG into the biosphere (GreenPeace India, 2010).

Massive investments have been capitalised in transport (metro, ferries, buses). To cope with 77 million potential international visitors for the Expo 2010, metro and railway networks have been expanded. Currently, metro network is considered as the third largest after London and New York. Using public transportation reduces drastically GHG emissions and therefore improves air quality (Cui & Shi, 2012). The city applied a control of polluting emissions from motor vehicles. 150 thousands highly polluting motor vehicles have been withdrawn for the road network of Shanghai since the 2000's. The whole taxis' fleet of Shanghai has met a certain standard of emissions, so the exhaust pollution can be kept under control. Those vehicles will be forbidden in certain areas of inner city. After improving public transportation offer, Shanghai decided to deter inhabitants using private vehicles by setting some policies of expensive license plate number. By fixing the price in auction around 14,000$, it is often unaffordable for citizens to buy the car and the license (Bloomberg News, 2013). The goal was to reduce road congestion while improving air quality. This policy has been published to attract a common understanding of the population. Subsidizes were also attributed to replace less polluting and energy efficient vehicles. In 2013, the city implemented a comparable European standard for vehicles emissions. Officials will ensure that 60% of the coming bus fleet is based on clean energy (natural gas, electricity and fuel cell).

The whole concept of Sustainable development popped up in 2009**.** 4 main posts compose the 12th plan: reducing polluting emissions, enforcing prevention and control of environmental risks, dealing with environmental problems of citizens and maintaining structural adjustment. Shanghai has involved public opinion into the decision in order to improve results. Complaints of citizens are used to expand environmental governance or specific local policies. It has helped to involve the inhabitants into the process of economic development; the social aspect of sustainable development became a real apprehension. Fighting the noise pollution was a worthy illustration of it. Officials began to use public opinion. School will be shutdown and heavy polluting vehicles will be forbidden in case of smog.

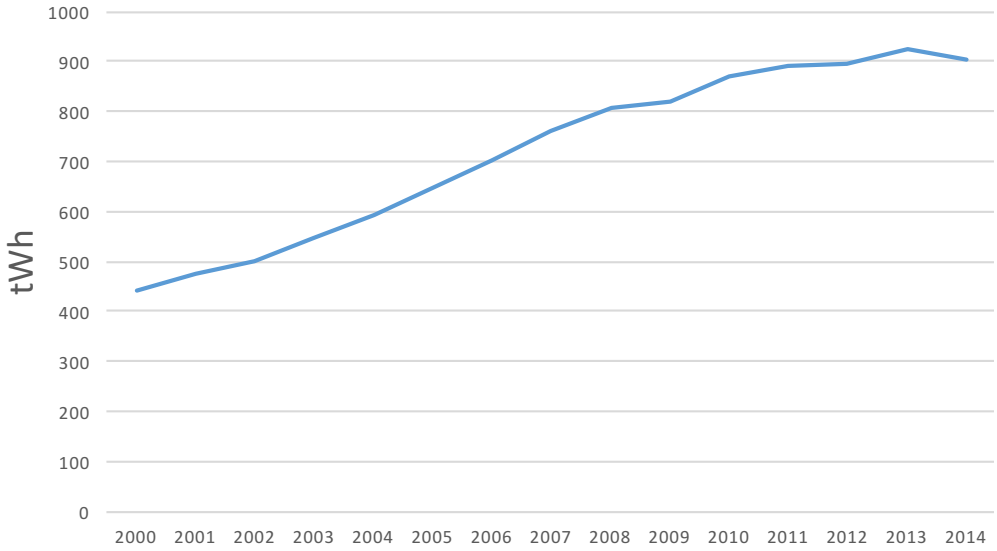


Figure 23: Energy Consumption of Shanghai from 2000 to 2014. Source: Chinese Statistical Yearbook (2015)

How successful were all those measures? As shown in Figure 23, 2013-2014's transition epitomizes a peak for energy consumption for Shanghai. Since its growth, energy consumption in Shanghai has been rising. It can be partially explained by a decrease of energy consumption in its industry, which accounted for 53% of its global consumption. The local structural change has, is and will reshape the economic structure of Shanghai 's GDP. According to Statistical Yearbook, China is not facing the same decrease of energy consumption; that positions Shanghai in a diverse situation. This down trend could be explained with the EKC. It symbolizes entirely the peak of high environmental degradation. Since then, more concerns are focused on the environment. As explained before, energy intensity of Shanghai is also facing down.

Table 10: Electricity power Consumption in Shanghai.

	2000	2013	2014
Power Consumption (100 million kwh)	559.51	1,410.6	1,369.03
Agriculture	9.1	7.45	7.26
Industrial	392.97	799.45	785.64
Transportation, Storage and Post Industry	5.94	40.34	41.26
Commercial, Hotel and Eateries	41.81	77.82	76.45
Finance, Real Estate, Commerce and Residential Service	25	159.68	164.95
Public Affairs and Administrative Organization	23.18	89.93	88
Urban Residential Consumption	53.2	205.04	173.89

Source: Chinese Statistical Yearbook (2015)

On Table 10, in terms of electrical consumption, structural changes can be similarly perceived. The consumption's trend is actually decreasing after 2013. It is particularly the case for industry sector. However, transport and finance (seen as tertiary sector) are increasing. Here is the illustration for electricity but the same can be perceived with other energies sources. That confirms the structural change and the development of tertiary sector as described in the first chapter. Shanghai wants to establish as the economic and financial center of East Asia, competing with other cities in the region such as Tokyo, Seoul, Hong Kong, and Taipei by developing a strong service economy (Yue & al, 2014). The industry structure changes in response to industrialization. With the industrialization process, the tertiary industry such as transport, finance, services, law, medical treatment, education, and myriad others, is bound to rise (Li & al, 2017). This may explain the shift downwards for Shanghai and the EKC. Scientific progress, technological advancement, and specific policies could also be a motive for the shift.

6.2.4 Comparison with national plans

As Table 11 indicates, Shanghai has followed the direction guided by the Central Government. Firstly, the increasing share of tertiary sector has been also more important for Shanghai than for overall China (64% for Shanghai and 48% for China). It could partially explain the dropping trend of energy consumption. This is also true for the energy scheme: adjustment of the energy structure, increasing of renewable energy and improve energy efficiency.

Shanghai included in the plans all the challenges previously described. For air and water quality, Shanghai has formerly tackled the problem (restring PM2.5, identifying several pollutants in air and water). Shanghai has proceeded to reduce its emissions following goals of National plans. Generally speaking, air quality and water pollution limits are set higher in comparison with national goals. It is easily understandable with the high-density of population, the health issue caused by air pollution and the proximity of water flows around the city of Shanghai. Shanghai is able to work on smaller scale and to perform particularly specific or local measures. This is the reason why circular economy is promoted. Then, noise pollution is considered as a threat for Shanghai, which is not measured as important for the National plans. Furthermore, Shanghai disposes of precise monitor systems to control daily emissions or pollutants concentrations. Shanghai is seen as the local level of action.

Table 11: Comparison National and Shanghai plan.

12th National Plan	**4th Shanghai plan**
2011-2015	2009-2011
Aquatic Environment Rehabilitation & Protection	Aquatic Environment Rehabilitation & Protection
Ambient Air Pollution Control and Protection	Ambient Air Pollution Control and Protection
Disposal and Utilisation of Solid Waste	**Noise Pollution Control** & Disposal and Utilisation of Solid Waste
Industrial Pollution Control, Cleaner Production and Circular Economy	Prevention and Control of Industrial Pollution
Agricultural Pollution Control & Rural Environment Protection	Agricultural and Rural Environmental Protection
Ecological Conservation and Environmental Infrastructure Construction	Ecological Conservation and Construction
	Circular Economy & Cleaner Production

Source: SEPB (2010)

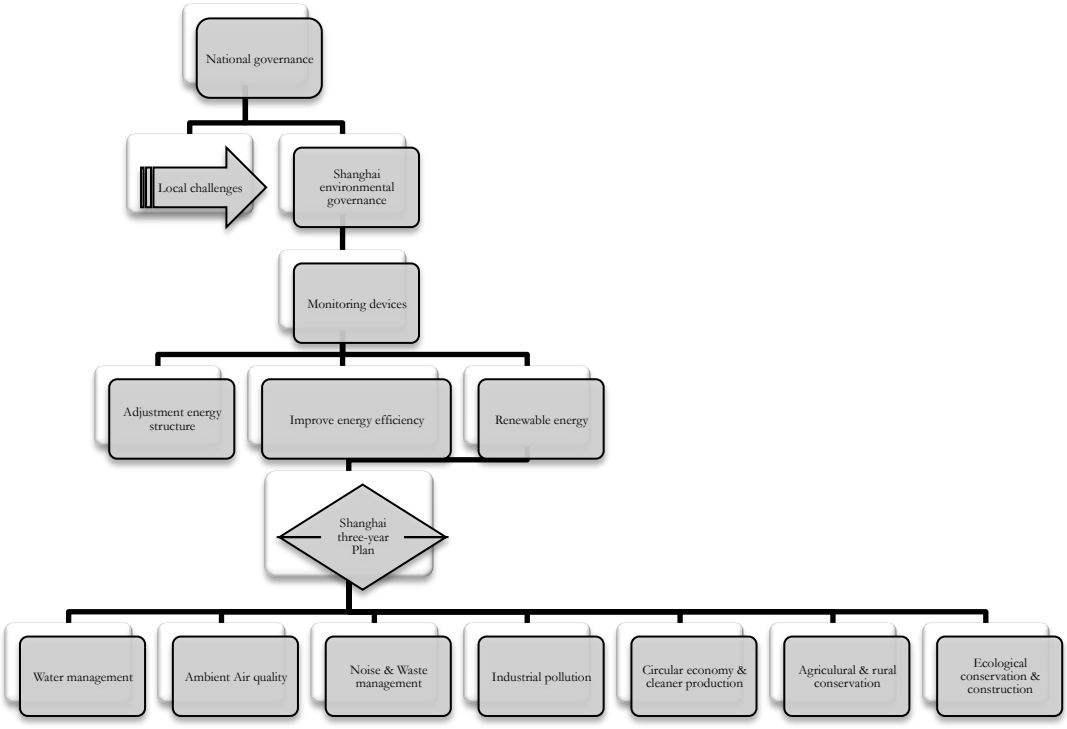


Figure 24: Summary of Shanghai environmental governance.

Figure 24 represents a summary of Shanghai environmental governance. Shanghai has followed instructions coming from various Plans of the Central Government. The municipality has personalized and strengthened some aspects of the plan according to the faced challenges. Shanghai has developed advanced monitoring systems of control to evaluate local progress and overall achievements. Then, Shanghai has followed National energy strategy based on 3 major pillars: adjustment of the energy mix, improve the energy efficiency and increase the share of renewable energy. This base was the first step to implement a successful and efficient suite of evolutionary plans to reach the settled objectives.

Table 12: Summary of environmental sustainability for Shanghai

Environmental Management	**Targets 2020**	**Achieved in 2015**
Forest & soil	30% forest coverage	Around 15% - Half achieved
Waste & recycling	N/A	Increased the number of incinerators and garbage treated
Energy efficiency	Diminishing energy intensity and new building regulations	Achieved
Water	Decrease in amounts of ammonia nitrogen & phosphorus in 2020	Achieved except phosphorus. 3 areas of 6 classified better, 3 unchanged.
Air quality	More AQI with excellent quality, decrease in amounts of pollutants (PM2.5, SO_2, CO_2, CO)	Achieved with some exceptions (PM2,5 and CO higher than 2014)
Adaptation/mitigation	Both used – no real target	Achieved
Circular economy & noise pollution	Developing more projects and keeping noise stable	Achieved

Source: own construction

Finally, as Table 12 specifies, Shanghai has proceeded to a strong sustainable development framework. It has focused on all pillars, not only environmental but also social and economic Majority of the targets have been successful even if all of them are not entirely quantifiable. Shanghai governance does not differ from Chinese one; most of the objectives were common to the National Goals with few exceptions: circular economy and noise pollution absent in Chinese National Plan & PM2.5 & AQI higher for Shanghai. Some other goals, such as decrease in carbon emissions per unit of GDP, share of renewable energy; are not in the Table for the reason that they are implied and not clearly identified in the UN framework of Figure 14. That confirms the fact that sustainable development is an evolutionary process. Whereas those goals remain ambitious, it is easier for a Chinese city to implement it. Central Government owns impressive force to close down some factories. That situation may confront some ideals of democracy in other emerging countries.

7. Conclusion

Shanghai has experienced an incredible rapid growth since the Chinese market reforms in 1978. This growing industrialization process has requested a booming demand in energy. Experts have detected an interaction between economic development and environment protection; often called the Environmental Kuznets Curve. That has comparably come in conflict with the concept of Sustainable Development and polluting emissions. Cities conserve a key position to generate consequential contributions towards the reduction of greenhouse emissions.

The aim of this present thesis is to comprehend how did Shanghai adapt its environmental governance to maintain a stable economic expansion. This thesis also tried to understand how did Shanghai incorporate Sustainable Development in its environmental governance. Whereas the concept concerns several pillars, this thesis focused on environmental aspect of the framework. Among all environmental facets, Shanghai heavily regulated soil, water, waste; air management, energy efficiency and mitigation to climate change. Through a detailed analysis of relevant literature from various sources, Shanghai has developed a strong sustainable development concept in its environmental governance in a sense that all pillars and challenges are confronted. Following the direction of National Plans, Shanghai has settled various evolutionary schemes in energy to tackle several faced challenges such as air quality, adaptation of climate change and the problematic of energy.

Environmental policy of Shanghai does not differ entirely from the Chinese governance. However, the outcomes of similar guidelines are different; the decrease of energy consumption and the structural adjustment in Shanghai is more important than China. Shanghai has implemented a strict and continuous environmental policy by following Chinese National Goals and adding stronger municipal goals. Shanghai decided to use not only adaptation but also mitigation toward climate change. The city deployed several schemes to attain the Low Carbon Megapolis. The entire strategic plan was implemented with rigorous governance with penalties and subsides to provide a large-scale direction for the actors of the economy. Shanghai has allocated increasing budget for environment protection; that could be outlined as an intensifying attention to this challenge. Adjustment in the economy structure has been accomplished: Shanghai has

moved successfully to a service economy leaving heavy pollution in the past. The tertiary sector is now leading and impacts largely the energy utilization. Then, a reformation in its energy mix was planned and this process is still on going. The city decided to quit the coal dependency and increase the share of cleaner energies. For instance, consumption of natural gas or electricity has increased. A particular attention was granted to renewable energies; plenty of projects in wind and solar energy have flourished throughout the districts. However due to the high density and the natural constraints, the potential share of green energy won't be sufficient to sustain the local demand. The way is long but immense efforts have been made. Then, to make this modification successful, Shanghai improved its energy efficiency with modern techniques and investments in R&D. Public transport was extended, consumption was reduced, strengthened standards in construction and several others formerly described. Shanghai adopted some leapfrogging techniques in the energy sector.

Consequently, the city reduced considerably polluting emissions and the air quality has enhanced. Expo 2010 symbolized undeniably a determinant accelerator to attain sustainable development and the eco-city. Shanghai Environment Protection Committee ensured the reinforcement of such policies by strictly measuring with advanced daily monitoring systems. Moreover, data demonstrated a turning point after 2013 in the energy consumption. Energy consumption began to fall. Other statistics show encouraging results in air and water quality, waste disposal or green protection for decades. Shanghai may also represent a typical illustration for the Environmental Kuznets Curve. After a prosperous economic development, Shanghai has reached the turning point and since then environmental degradation seems to drop. The weak hypothesis could explain the relative decrease of CO_2 emissions (Kander, 2002). However, the city is up to the present time threatened by various challenges. Whereas the environmental governance of Shanghai could be considered as successful, the city is now facing a pressuring urbanization, high GHG emissions, climate change, road congestion, rural migration and a growing population. It also seems that Shanghai has just displaced polluting industries outside the province, confirmed by the major difference in the GDP structure of Shanghai and China. Those challenges may require further researches.

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